UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF ILLINOIS
EASTERN DIVISION

ClearOne, Inc., Plaintiff, vs. Shure Incorporated, Defendant.	Civil Number 1:19-cv-02421 Hon. Edmond E. Chang Jury Trial Demanded **[REDACTED VERSION]**

FIRST AMENDED COMPLAINT FOR PATENT INFRINGEMENT, TRADE SECRET MISAPPROPRIATION, TORTIOUS INTERFERENCE WITH PROSPECTIVE ECONOMIC ADVANTAGE, AND TRADE LIBEL

Plaintiff ClearOne, Inc. ("ClearOne") files this Amended Complaint against Defendant Shure Incorporated ("Shure"), and alleges as follows:

INTRODUCTION

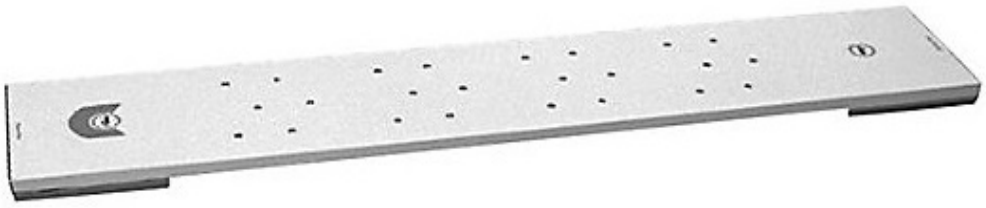
1. ClearOne brings this action to stop Shure from its predatory actions against ClearOne, including wrongful and willful infringement of ClearOne's market-leading, patented audio conferencing technologies; intentional misappropriation of ClearOne's valuable trade secrets related to its products; and tortious interference with prospective economic advantage and trade libel based on a false statement made by Shure about ClearOne.[1]

2. Despite being a small public company, ClearOne had grown into the global market leader in the installed audio conferencing market and a leading provider of premium audio conferencing systems and other related products for audio, video, and web conferencing

[1] Pursuant to Shure's objection to public disclosure of internal Shure documents and related material, ClearOne has redacted references to specific evidence of Shure's trade secret misappropriation from the public version of this First Amended Complaint.

applications. As a market leader, ClearOne is focused on developing cutting-edge conferencing and collaboration products. Through decades of innovation, investment, and effort by ClearOne's inventors and engineers, ClearOne has developed industry-leading products and a portfolio of approximately 100 issued patents and pending patent applications.

3. No later than 2010, ClearOne inventors conceived and developed a beamforming microphone conferencing system that was designed to replace up to a dozen individual microphones with a compact beamforming microphone array that could be placed overhead or otherwise out of the way and yet have superior audio quality and clarity. Over the next several years, ClearOne developed this beamforming microphone conferencing system and also conceived and developed other inventions involving related technology. In 2012, ClearOne was first to market with this beamforming audio conferencing technology – the Beamforming Microphone Array ("BMA") audio conferencing system – which combined beamforming with acoustic echo cancellation and adaptive steering or smart beam selection to provide superior audio performance and clarity.



4. To protect its industry-leading technology, ClearOne filed provisional and utility patent applications, including United States Patent Application No. 13/493,921 (the "'921 Application") entitled "Methods and Apparatuses for Echo Cancelation with Beamforming Microphone Arrays." The '921 Application issued as United States Patent No. 9,264,553 (the "'553 Patent"). A true and correct copy of the '553 Patent is included as Exhibit A.

5. Once it was ready to sell the BMA, ClearOne encountered the issue of how to price the BMA conferencing system. Since ClearOne's beamforming microphone conferencing system was unique in the market, there was little precedent for what ClearOne should charge for the system. Accordingly, ClearOne spent significant time and effort developing highly confidential pricing lists for the BMA, including standard discounts to appeal to manufacturer representatives, dealers, resellers, and distributors, and special pricing to drive sales of this new product.

6. These highly confidential price lists carry significant value to ClearOne, and a competitor's access to these price lists would harm ClearOne's ability to compete. By maintaining the price lists confidentially, ClearOne is able to offer preferential pricing and confidential discounts. Indeed, even ClearOne partners are not permitted to share pricelists with other partners because pricing differs among different ClearOne partners. This enables ClearOne to sell more of its products and thereby positions ClearOne as the most price-effective solution. And it allows ClearOne to maintain fair pricing among various partners and partner levels. If the price lists were made public or released to ClearOne's competitors, the competitors could simply undercut ClearOne's prices (or offer more advantageous bundle pricing) and thereby steal customers that could have otherwise bought ClearOne products. And by continually undercutting ClearOne prices, the competitors would gain goodwill and reputational benefits by appearing to be more price-competitive than ClearOne. In addition, knowing ClearOne's price lists would help the competitors better position their products in the market and save significant time in price discovery (a process where the manufacturer keeps adjusting prices to get the desired sales volume).

7. Accordingly, ClearOne maintains these lists as trade secrets, including by

restricting access to them both internally and externally to only those who need to use or see them (those with a "need to know") in order to further ClearOne's business. And before sharing these highly confidential price lists with a limited number of manufacturer representatives, dealers, resellers, distributors, and employees, ClearOne marks them "Confidential" and includes strict confidentiality clauses in its contracts to protect the price lists from disclosure.

8. Due to the innovative nature of ClearOne's BMA and the BMA's significant commercial success upon entry into the market, ClearOne has been recognized several times for its continued innovation and excellence in the installed audio conferencing market.

9. Shure is a large microphone and audio company that sells products throughout the world. Witnessing the success of the ClearOne BMA in the audio conferencing market, Shure embarked on a coordinated campaign to capture market share from ClearOne. But it went about doing so in an unfair and improper manner. Within three years of the BMA's release, Shure released its own competing products: the MXA910 Ceiling Microphone Array ("MXA910") and the Microflex Advance Table Array microphone (the "MXA310"). The MXA910 and MXA310, as designed and operated, make pervasive use of ClearOne's patented technology and infringe ClearOne's '553 Patent.

10. [redacted]

[redacted]

11. One month ago, ClearOne won a motion for a preliminary injunction against Shure ("PI Order") to stop Shure's ongoing infringement of ClearOne's U.S. Patent No. 9,813,806 ("'806 Patent"). As part of its efforts to inform market participants of the PI Order, ClearOne widely distributed a letter that quoted the PI Order to identify the Court's restriction on Shure's ability to manufacture, market, or sell the MXA910 for use in a drop-ceiling mounting configuration, and informed those market participants that ClearOne intended to continue its efforts to protect its intellectual property rights. In response, Shure widely distributed its own message to market participants, falsely claiming that ClearOne's letter made "false statements." Shure's message improperly defamed ClearOne in the marketplace, interfering with its prospective business relationships and leading one potential partner to claim that he would "go out of [his] way to never specify or purchase another product from Clear One [sic]."

12. ClearOne files this Complaint to hold Shure responsible for its deleterious conduct and prevent it from further harming ClearOne. ClearOne seeks injunctive relief barring Shure from infringing ClearOne's patented technology,from further acquiring and using ClearOne's trade secrets, and from further making false statements about ClearOne, damages for Shure's past infringement, trade secret misappropriation, and effects of its false statements, punitive and treble damages to hold Shure responsible for its conduct, and ClearOne's attorneys' fees and costs associated with this action.

JURISDICTION AND VENUE

13. ClearOne's claim for patent infringement arises under the Patent Laws of the United States, 35 U.S.C. § 101 et seq. ClearOne's claim for trade secret misappropriation arises

under the Defend Trade Secrets Act, 18 U.S.C. § 1836, et seq. Accordingly, this Court has subject matter jurisdiction over this Complaint and Shure pursuant to 28 U.S.C. §§ 1331, 1338(a), 1367. This Court also has jurisdiction over this dispute under 28 U.S.C. § 1332.

14. This Court has personal jurisdiction over Shure in this matter. Among other things, Shure's headquarters are located at 5800 West Touhy Avenue in Niles, Illinois 60714 and it regularly transacts business in Illinois. Shure has also caused injury to ClearOne in Illinois through its willful patent infringement and trade secret misappropriation.

15. Venue is proper in this district under 28 U.S.C. §§ 1391(b) & (c) and/or 1400(b).

PARTIES

ClearOne, Inc.

16. ClearOne is a small public corporation, incorporated in Utah, with a principal place of business at 5225 Wiley Post Way, Suite 500, Salt Lake City, Utah 84116.

17. ClearOne was founded in 1983. Since its inception, ClearOne has grown to become a company dedicated to the design, development, marketing, and sales of conferencing, collaboration, and network streaming solutions for voice and visual communications. ClearOne has created hundreds of new products that improve people's ability to collaborate and communicate, whether they are in the same room or on opposite sides of the globe.

18. ClearOne's commitment to innovation and quality in the field of voice and visual communication solutions is well known. ClearOne has developed several industry firsts including, but not limited to:

- First professional-grade Beamforming Microphone Array ("BMA");
- First product to use Distributed Acoustic Echo Cancellation in an audio conferencing system;

- First conference phone to provide wireless conferencing;
- First fully-scalable conference phones that daisy-chain multiple phone units;
- First product to bridge the wide price/performance gap that existed between plug-and-play tabletop conferencing phones and professionally-installed audio conferencing systems; and
- First product that is a complete professional video collaboration system with state-of-the-art audio and video technology, and a patented ceiling tile beamforming mic array designed for medium and large meeting rooms.

19. ClearOne's BMA-CT product, a ceiling tile beamforming microphone array, practices, among other patents, its '553 Patent and '806 Patent.

20. Today, installed audio conferencing is one of ClearOne's core businesses, and, before Shure's willful infringement and misappropriation, ClearOne had become the market leader in that field, with over 50% of the global market. ClearOne's products have been used by thousands of organizations worldwide, including schools, government entities, medical facilities, law firms, businesses, and houses of worship.

Shure Incorporated

21. Shure is a private corporation, incorporated in Illinois, with its principal place of business at 5800 W. Touhy Avenue, Niles, Illinois 60714.

22. Shure designs and manufactures audio systems. Shure's products include wireless and wired microphone systems, digital signal processors, and personal monitor systems, among others. Shure is a competitor of ClearOne.

23. Shure advertises, encourages, and instructs its customers to make and use integrated systems consisting of its beamforming microphones (such as the Shure MXA910 and

MXA310), as well as acoustic echo cancellation products from other companies (such as QSC's Q-SYS platform and Biamp's Tesira/TesiraFORTE audio processors and software).

24. The performance of these integrated systems plays a key role in Shure's ability to compete effectively in the audio-visual conferencing market.

25. Shure is aware that ClearOne has patents relating to beamforming audio conferencing systems.

26. [redacted]

RELEVANT NONPARTIES

Biamp Systems Corporation

27. Biamp is a private corporation, incorporated in Delaware, with a principal place of business at 9300 S.W. Gemini Drive, Beaverton, Oregon 97008.

28. Biamp designs and manufactures audio and video systems. Biamp's product[redacted] include networked digital audio platforms, digital signal processors, and scalable media systems for digital audio networking, among others. Biamp is a competitor of ClearOne.

29. Biamp advertises, encourages, and instructs its customers to make and use integrated systems consisting of its acoustic echo cancellation products (such as its Tesira/TesiraFORTE audio processors and software) and the Shure MXA910 and MXA310 microphones.

30. The performance of these integrated systems plays a key role in Biamp's ability to compete effectively in the audio conferencing market.

31. Biamp is aware that ClearOne has at least two patents relating to beamforming

audio conferencing systems.

QSC, LLC

32. QSC is a private company organized as a California limited liability company with its principal place of business at 1675 MacArthur Blvd., Costa Mesa, California 92626.

33. QSC designs and manufacturers audio systems. QSC's products include power amplifiers, loudspeakers, audio DSP mixers, and networked audio and control. QSC is a competitor of ClearOne.

34. QSC advertises, encourages, and instructs its customers to make and use integrated systems consisting of its acoustic echo cancellation products (such as its Q-SYS platform) and the Shure MXA910 and MXA310 microphones.

35. The performance of these integrated systems plays a key role in QSC's ability to compete effectively in the audio conferencing market.

36. QSC is aware that ClearOne has at least two patents relating to beamforming audio conferencing systems.

BACKGROUND OF THE TECHNOLOGY

37. The technology at issue in this case pertains generally to the field of digital signal processing techniques, as used primarily in audio and video teleconferencing systems that are often deployed in conference rooms.

38. Beamforming, also known as spatial filtering, is a signal processing technique used in sensor arrays for directional signal transmission or reception. Beamforming can be used to select desired sound sources, while rejecting unwanted sounds. In an audio conferencing system, beamforming can be used to select, or focus on, a participant's voice, while rejecting noise and interfering speech, in order to provide superior audio performance and clarity.

39. Another related and important technology in audio conferencing is acoustic echo cancellation. Acoustic echo cancellation involves recognizing an echo, and then reducing or removing it by subtracting it from a transmitted signal. For example, during an audio conference, the voice of a speaker on one end of a conference line is output through speakers at the other end of the conference line. Often, that speaker output is then picked up by the microphones on the same end of the conference line, and relayed back to the original speaker as undesirable echo. Acoustic echo cancellation reduces, eliminates, or minimizes this effect.

40. ClearOne was at the forefront of integrating beamforming microphone arrays with acoustic echo cancellation. ClearOne's '553 Patent covers methods and apparatuses that, among other things: (1) perform a beamforming operation that combines a plurality of microphone signals into a smaller number of combined signals that each correspond to a different fixed beam; and (2) performs an acoustic echo cancellation operation on the combined signals.

41. The '553 Patent employs a particular "hybrid" method, wherein microphone signals are beamformed into a plurality of fixed beams, and echo cancellation is then applied to those fixed beams. Performing the echo cancellation step on pre-formed, fixed beams minimizes the computer processing effort involved in acoustic echo cancellation, while also keeping the absolute number of echo cancellers to a minimum. This solves two problems that plagued other methods at the time of invention of the '553 Patent.

42. Ashutosh Pandey, Darrin Thurston, David Lambert, and Tracy Bathurst, the inventors of the '553 Patent, created the methods recited therein after unsuccessful attempts to develop other beamforming and echo cancellation technologies. For example, Mr. Pandey and his team members worked for over a year on a project that performed acoustic echo cancellation first, and then conducted beamforming using the output of each microphone signal. This project

was ultimately scrapped due to high costs, high processing requirements, and insufficient sound quality.

43. Pandey and his co-inventors then went back to the drawing board and began developing a beamforming microphone array that would use fixed beams. Ultimately, they realized that they could dramatically reduce processing requirements and achieve excellent sound quality by *first* using a digital signal processor ("DSP") to perform a beamforming algorithm and *then* performing AEC on the signals of each fixed beams, rather than performing AEC on the output of each microphone. The result was a new technology with significant cost and processing improvements and excellent sound quality. It is this new technology that is described and claimed in the '553 Patent.

44. ClearOne currently employs the technology in the '553 Patent in its Beamforming Microphone Array and CONVERGE Pro products, both of which are now in their second generation. ClearOne also employs the technology in its BMA CT ceiling tile beamforming microphone array, ClearOne's third-generation product.

SHURE'S INFRINGEMENT OF CLEARONE'S '553 PATENT

45. In or around January 2016, Shure announced the release of its MXA910 (Ceiling Array) and MXA310 (Table Array) microphones. The microphones began shipping later that year, in August 2016. Shure continues to sell both microphone products today.

46. The Shure MXA910 and MXA310 microphones utilize the technology in the '553 Patent. Both Shure microphone products offer the same beamforming as that claimed in the '553 Patent. Specifically, they, among other things: perform a beamforming operation with a beamforming module; combine "[m]ultiple mic elements together to produce multiple, highly-directional pickup lobes"; and combine a plurality of microphone signals such that each of the

plurality of combined signals corresponds to a different fixed beam.

47. Shure's MXA910 and MXA310 microphones also require acoustic echo cancellation ("AEC"). To provide this functionality, Shure directs end users to use digital signal processors with Shure's MXA910 and MXA310 microphones. At first, Shure encouraged the use of QSC's Q-SYS platform and Biamp's Tesira/TesiraFORTE audio processors and software—both of which provide the required AEC—with their MXA910 and MXA310 microphones. Now, Shure also offers its own digital signal processor, the Shure IntelliMix P300.

48. Combined with a DSP, the Shure MXA910 and MXA310 microphones offer the same combination of beamforming and acoustic echo cancellation as ClearOne's BMA. In fact, upon its release of the MXA910 and MXA310, Shure become the only company in the United States to sell a substantially similar beamforming microphone array to ClearOne's BMA. Shure's infringement, on its own and in combination with others, has harmed ClearOne's investments in technology and its reputation as a leader and innovator.

SHURE'S KNOWLEDGE AND WILLFUL PATENT INFRINGEMENT

49. Shure has knowingly infringed and willingly continued to infringe the '553 Patent by selling its MXA910 and MXA310 products, even after challenging ClearOne's '553 Patent in federal court and unsuccessfully with the PTAB.

50. On April 24, 2017, Shure filed an action in the U.S. District Court for the Northern District of Illinois seeking a declaratory judgment of noninfringement and invalidity of the '553 Patent. *Shure Inc. v. ClearOne, Inc.*, Case No. 17-cv-03078 (N.D. Ill.).

51. ClearOne had filed an application for reissue of the '553 Patent on April 16, 2017, prior to Shure's complaint. On July 14, 2017, Shure filed a petition for *Inter Partes* Review ("IPR") of the '553 Patent, and on January 29, 2018, the Patent Trial and Appeal Board

("PTAB") instituted IPR proceedings for the '553 Patent.

52. On March 16, 2018, the Court declined to exercise jurisdiction over Shure's declaratory judgment claim with respect to the '553 Patent, noting that "[t]he '553 patent is currently in reissuance proceedings before the Patent and Trademark Office, and the Patent Trial and Appeal Board recently granted *inter partes* review of the patent." (*See Shure Inc. v. ClearOne, Inc*., Case No. 17-cv-03078 at Dkt. 280.)

53. On January 24, 2019, the PTAB issued its unanimous Final Written Decision for the IPR of the '553 Patent, finding that Shure "ha[d] not demonstrated by a preponderance of the evidence that any of [the challenged claims] are unpatentable under 35 U.S.C. §§ 103(a)." (*See* Case No. 17-cv-03078 at Dkt. 478, Ex. A.) The PTAB panel which reached this decision consisted of three technically trained administrative patent judges: Dr. Kevin Turner (Ph.D., Physics), Joni Chang (B.Sc., Chemical Engineering), and Arthur Peslak (M.Sc., Mechanical Engineering). According to a 2017 publication, Judges Chang and Turner are two of the PTAB's most experienced patent judges; both Judge Chang and Judge Turner have presided over more than 400 PTAB trials.

54. Shure filed a Request for Rehearing ("Request") of the PTAB's Final Written Decision on February 22, 2019. Just over a month later, on March 25, 2019, the PTAB denied Shure's Request, holding, among other things, that Shure's contentions were "without merit," "not persuasive," and "unavailing." Under the law—including 35 U.S.C. § 325(e)(2)—Shure should be estopped from asserting invalidity of the '553 Patent "on any ground that [it] raised or reasonably could have raised during th[e] post-grant review."

SHURE'S MISAPPROPRIATION OF CLEARONE TRADE SECRETS

55. In the audio conferencing market, two of the principal factors that market

participants, including manufacturer representatives, dealers, resellers, and distributors, take into account when choosing a conferencing product are technology and pricing. As discussed above, the BMA became successful in large part due to its unique technology—yielding improved performance—and the functionalities it could offer because of that technology. But another important driver of success for the BMA—along with ClearOne's other products—was pricing.

56. Before the BMA was first released, ClearOne spent considerable time deliberating about what the right price should be for a product with such unique technology and resultant performance. It was an arduous task, because there was no directly competitive product that it could be compared to. Accordingly, ClearOne developed pricing for the BMA by examining, among other things, the benefits the BMA offered above and beyond benefits offered by existing products at the time, costs of procuring and installing existing products, and costs of manufacturing the BMA. ClearOne then worked into its pricing tiered discounts for its manufacturer representatives, dealers, resellers, and distributors based on purchasing volume and other factors. ClearOne developed this pricing to gain a competitive advantage over other products in the market.

57. Price lists are a "secret sauce" in the audio-visual conferencing industry. The publicly-available MSRP prices for conferencing products have only indicative value, as bids for projects are rarely won based on MSRP prices. Instead, dealers, integrators, and use resellers win bids by offering confidential discounts and preferential pricing. Industry participants thus take significant measures and time to develop their price lists, and to ensure that they are not being released to their competitors.

58. ClearOne memorialized its prices for the BMA and its other products in highly confidential distributor and dealer price lists, specific to each region that it operated in. In the

United States, ClearOne called these price lists "North America Pricing Guides." Price lists in the United States were offered under different tiers, namely Distributor, Platinum Dealer, Gold Dealer and Dealer. ClearOne shared these price lists with its manufacturer representatives, dealers, resellers, and distributors to ensure that they had up-to-date pricing—applicable to particular distributors or dealers based on the tier to which they belonged—when deciding between ClearOne and other products for end users. And ClearOne ensured that the dealers, resellers, and distributors got access to only the price list applicable to them based on whether they were a Distributor, a Platinum Dealer, a Gold Dealer, or a Dealer.

59. Although ClearOne had to share its highly confidential price lists to carry out its business, ClearOne took numerous steps to keep the price lists confidential, and especially to keep the price lists out of the hands of ClearOne's competitors. It was—and is—important for ClearOne to keep the price lists secret because the price lists provide ClearOne a competitive advantage in selling its products. ClearOne strategically uses the price lists to offer confidential discounts and preferential pricing to be competitive and win projects. ClearOne has a clear advantage in the market when it can provide the best conferencing product at the best prices. However, if the price lists were disclosed publicly, competitors—like Shure—could use the knowledge of ClearOne's confidential discounts and preferential pricing to undercut ClearOne's prices. The competitors would then be positioned as the more price-efficient conferencing option and would gain goodwill from manufacturer representatives, dealers, resellers, distributors, and end users at the expense of ClearOne. In addition, even if competitors who got access to ClearOne's highly confidential price lists did not use those lists to undercut ClearOne's prices, they could use their knowledge of ClearOne's prices to, among other things, protect their price from getting too low and save time by not bidding for projects that they know, based on

ClearOne's prices, would not let them obtain the required margins. Moreover, competitors could quote a slightly lower price than they would otherwise—even if higher than ClearOne's—and then attempt to justify their only-slightly-increased price to purchasers.

60. ClearOne's efforts to maintain the confidentiality of the price lists started with marking every page of the price lists with a "ClearOne Confidential" stamp to make it clear to any reader that the price lists were (and contained) ClearOne's confidential information.

61. Internally, ClearOne locks down and secures access to the highly confidential price lists. IT restricts access to the price lists to only those ClearOne employees who have a need to access and view the price lists—*e.g.*, an engineer does not have access to the price lists. If an employee without access wants to obtain access to the price lists, the employee needs to get authorization from his/her manager and then also obtain authorization from the ClearOne Sr. Vice President of Finance. Once granted access, the employee only has access to the specific price lists they require, not every ClearOne price list. For example, sales persons only have access to the price lists applicable to their regions. These strict requirements are part of ClearOne's internal IT controls that are key to its public reporting and in compliance with the requirements of the Sarbanes-Oxley Act of 2002. These practices and policies have been in place at all times relevant to this lawsuit.

62. Moreover, ClearOne employees are, as a condition of their employment, required to execute a non-disclosure agreement in which they agree, among other things, not to improperly use and/or disclose ClearOne confidential information and trade secrets during or after the course of their employment at ClearOne. ClearOne employees are reminded of their covenants of confidentiality throughout their employment, including in the Employee Handbook, which they need to periodically sign to acknowledge receipt and understanding. Employees'

confidentiality obligations pursuant to these signed agreements apply throughout their employment and beyond termination.

63. Similar restrictions apply to external recipients, including sales channel partners such as manufacturer representatives, dealers, resellers, and distributors. Before sending any highly confidential price lists, ClearOne requires external recipients to sign agreements with broad confidentiality clauses that prohibit them from disclosing this confidential information to anyone outside of ClearOne's sales channel or to anyone without a need to know. For example, one such confidentiality clause states:

> "Reseller understands and acknowledges that in order to facilitate the business arrangements contemplated by this Agreement, certain confidential and proprietary technical, financial and/or business information of ClearOne will be disclosed to Reseller. This confidential and proprietary information includes, without limitation, all proprietary inventions, sales support materials, processes, product design(s), drawing and schematics of product design(s), methods of doing business, pricing, marketing programs, and other data and information, whether patented or not, heretofore or hereafter developed or acquired by ClearOne in the course of the design, manufacture, marketing, or sale of or otherwise relating to the Products or future conceptual or unreleased products. Reseller acknowledges that all ClearOne Confidential Information is the exclusive property and trade secrets of ClearOne. Reseller agrees not to use or disclose any ClearOne Confidential Information in any manner adverse to the best interests of ClearOne."

Finally, ClearOne only sends external partners the specific price list applicable to them, which depends on their region and purchasing tier. For example, a dealer in Illinois in March 2016 would only receive the North American Dealer price list for March 2016 that relates to that

dealer's partner level, not the price lists for any other region, any other period, or any other partner level. ClearOne transmits the highly confidential price lists via e-mail to external partners in e-mails that state that the "electronic mail message and any attachment is confidential."

64. [redacted]

65. [redacted]

66. [redacted]

67. [redacted]

[redacted]

68. [redacted]

69. [redacted]

70. Shure's brazen and illegal conduct has yielded it considerable benefit. [redacted]

[redacted]

71. The effects on ClearOne are also clear: among other things, lost sales and loss of goodwill due to Shure's anticompetitive behavior.

SHURE'S FALSE STATEMENT AGAINST CLEARONE

65. Since April 2016, ClearOne and Shure have been engaged in litigation in the Northern District of Illinois concerning ClearOne's allegations that Shure is infringing ClearOne's '806 Patent and U.S. Patent No. 9,635,186 by selling its MXA910 product. *See Shure Inc. v. ClearOne, Inc.*, No. 17-cv-03078 (N.D. Ill.).

66. On August 5, 2019, the Honorable Edmond E. Chang granted ClearOne's motion for preliminary injunction to halt Shure's infringement of ClearOne's '806 Patent. In relevant part, the PI Order stated:

> Shure shall cease manufacturing, marketing, and selling the MXA910 to be used in its drop-ceiling mounting configuration, including marketing and selling the MXA910 in a way that encourages or allows integrators to install it in a drop-ceiling mounting configuration. This injunction applies to Shure's officers, agents, servants, employees, and attorneys, as well as anyone who is in active concert or participation with those listed persons. But Shure customers that have already installed the MXA910 in a drop-ceiling mounting configuration shall be permitted to continue using their MXA910s in that way, and Shure will be able to continue servicing those already-installed products.

A true and correct copy of the publicly-available version of the PI Order is attached here as Exhibit

P.

67. On August 29, 2019, ClearOne Senior Vice President of Finance Narsi Narayanan issued a letter concerning the "Installation of Shure MXA910 in a Drop-Ceiling Mounting Configuration." This letter stated:

> It has long been ClearOne's position that any installation or use of an MXA910 product in a drop-ceiling mounting configuration infringes ClearOne's U.S. Patent No. 9,813,806 (the "'806 Patent"). On August 5, 2019, a Court Order confirmed ClearOne's position. In that Order, (available at https://is.gd/injuncn), the Court held that "Shure is likely infringing the '806 Patent" by manufacturing, marketing, and selling the MXA910 to be used in its drop-ceiling mounting configuration, and issued a preliminary injunction order preventing Shure from manufacturing, marketing, and selling its MXA910 product for use in a "drop-ceiling mounting configuration." The Court's order also prevents Shure from encouraging others to use the Shure MXA910 beamforming microphone array in the "drop-ceiling mounting configuration" and "applies to Shure's officers, agents, servants, employees, and attorneys, as well as anyone who is in active concert or participation with those listed persons."
>
> The Court's infringement analysis applies equally to third parties such as integrators and consultants. If Shure is likely infringing the '806 Patent by manufacturing, marketing, and selling the MXA910 product to be used in a drop-ceiling mounting configuration, then third-party integrators are also likely infringing the '806 Patent if they install the MXA910 product in a drop-ceiling mounting configuration, and third-party consultants are likely inducing infringement if they recommend installation of the MXA910 product in a drop-ceiling mounting configuration.
>
> Please be aware that it is likely an act of infringement to install a Shure MXA910 product (Model Nos. MXA910B, MXA910W, MXA910AL, MXA910B-60CM, MXA910W-60CM, and MXA910AL-60CM) in a drop-ceiling mounting configuration. This is so regardless of when, or how, the installing company received the MXA910 that it installs. Please also be aware that a finding of willful patent infringement may result in the infringer having to pay treble damages pursuant to 35 U.S.C. § 284.
>
> We thank you in advance for your understanding of ClearOne's efforts to protect its intellectual property rights. Please contact me with any questions or concerns.

This letter (the "Narayanan Letter") was then transmitted to integrators, consultants, and other market participants that are in the business of assessing installed audio-conferencing products. A true and correct copy of the Narayanan Letter is attached here as Exhibit Q.

68. On September 4, 2019, Shure transmitted a message to market participants about

the Narayanan Letter. In relevant part, it stated:

> This letter is prompted by the fact that ClearOne recently distributed additional communications to the marketplace relating to the patent litigation. You may have received a letter dated August 29, 2019 from ClearOne's CFO [sic] Narsi Narayanan, in which ClearOne again tries to misinform, mislead, and seemingly intimidate and threaten customers in the marketplace, by both making false statements and omitting important facts about the scope and impact of the recent preliminary injunction granted by a federal court in Chicago on Shure's ability to supply and support MXA910 products. As before, the untruth of these marketplace statements has been examined by Shure's attorneys, and shortly, we will be amending our lawsuit in Delaware to include the falsity of the statements made in this recent ClearOne letter. But in the meantime, we wanted to take the opportunity to remind you of the limited effect of the Court's rulings.

A true and correct copy of the Shure's message is attached here as Exhibit R.

69. Shure's claim that ClearOne made "false statements" is itself false and clearly incorrect because none of the statements in the Narayanan Letter are incorrect. For example, ClearOne ***linked the PI Order*** in the Narayanan Letter and quoted it directly when it stated that it found that "Shure is likely infringing the '806 Patent" and that the injunction applied to installations of the MXA910 in a drop-ceiling mounting configuration. Moreover, ClearOne's belief that the PI Order's infringement analysis applies equally to third parties is its own reasonable opinion and thus cannot be characterized as a "false statement."

70. Upon information and belief, Shure sent its message to market participants in an effort to bias them against ClearOne by making them believe that ClearOne was spreading false information.

71. Upon information and belief, Shure's false statements about ClearOne caused market participants, including prospective ClearOne customers, to decide against choosing ClearOne products. For example, one such participant e-mailed ClearOne the morning after Shure's message and stated: "Because of this lawsuit and especially this letter I will go out of my way to never specify or purchase another product from Clear One."

72. Upon information and belief, ClearOne has lost sales and goodwill due to Shure's false statements.

COUNT I

Claim for Relief for Patent Infringement of the '553 Patent

70. ClearOne incorporates by reference paragraphs 1 through 72 and Exhibits A-R attached hereto.

71. ClearOne is the owner of all rights, title, and interest in the '553 Patent. The '553 Patent issued on February 16, 2016.

72. The '553 Patent is valid and enforceable. Indeed, under the law—including 35 U.S.C. § 325(e)(2)—Shure should be estopped from asserting invalidity "on any ground that [it] raised or reasonably could have raised" during the IPR Shure lost while attempting to challenge the validity of the '553 Patent.

73. Defendant Shure manufactures, uses, offers to sell, and sells beamforming microphone arrays and digital signal processing platforms and thereby directly infringes at least one claim of the '553 Patent. Shure advertises, encourages, and instructs its customers to make, use, offer to sell, and/or sell infringing integrated systems consisting of Shure's beamforming microphones (such as the MXA910 and MXA310) and digital signal processors that perform acoustic echo cancellation (such as Shure's IntelliMix P300, QSC's Q-SYS platform, and Biamp's Tesira/TesiraFORTE audio processors and software). Upon information and belief, the Shure beamforming microphones practice a material part of the claimed invention of the '553 Patent, have no substantial non-infringing use, and are marketed and sold to be used together with a digital signal processor that performs acoustic echo cancellation.

74. Shure's beamforming microphones are intended for audio and video

conferencing. *See, e.g.,* Exhibit H (Shure MXA310 User Guide Excerpt) at 1 ("The Microflex® Advance™ table array is a premium networked tabletop microphone for AV conferencing environments, including boardrooms, huddle rooms, and multi-purpose spaces."); Exhibit I (Shure MXA910 User Guide Excerpt) at 1 ("The Microflex® Advance™ Ceiling Array is a premium networked array microphone for AV conferencing environments, including boardrooms, huddle rooms, and multi-purpose spaces."). Upon information and belief, for audio conferencing purposes, the Shure MXA910 and MXA310 beamforming microphones require acoustic echo cancellation ("AEC"). The AEC functionality is provided to the MXA910 by digital signal processors such as by Shure's IntelliMix P300, QSC's Q-SYS platform, and Biamp's Tesira/TesiraFORTE audio processors and software. These integrated systems thus infringe the '553 patent, including by performing beamforming operations that combine microphone signals into signals corresponding to fixed beams, and then perform acoustic echo cancellation on the combined signals.

75. In addition, Shure has formed joint enterprises with several AV hardware and software providers, including both Biamp and QSC, to manufacture and sell these infringing integrated systems to customers. *See, e.g*., Exhibit J (2017-02-07 Press Release) ("Shure Expands Partnership Program With Leading AV Hardware and Software Providers … [including] Biamp, QSC …."); Exhibit K (QSC-Shure Software Integration Alliance (accessed Apr. 9, 2019)) ("Shure and QSC have co-developed a control plugin for their Microflex Wireless microphone series." In addition, specific microphones in the Shure catalog, including the Microflex Wireless series, can pass audio to the Q-SYS Platform via AES67, all without additional Dante I/O card hardware."); Exhibit L (2017-01-09 Press Release) ("QSC, LLC and Shure Incorporated are proud to announce an expanded level of integration between Shure

Microflex® Advance™ and Microflex® Wireless microphones with the entire Q-SYS™ Platform. The partnership includes the release of new control plug-ins for the Shure MXA910 Ceiling Array Microphone and Microflex Wireless microphone systems."); Exhibit M (2016-12-06 Press Release) (Biamp is "excited to come together with an industry leader like Shure in an effort to streamline the integration of [their] products"; "Adding Shure microphone-specific software blocks to [Biamp] Tesira's cutting-edge software made sense; it allows system designers to easily incorporate the power of Shure mics with the power of [Biamp] Tesira."); Exhibit N (2018-10-02 Biamp Article) ("The purpose of this article is to provide a starting point to aid in the successful deployment of the [Biamp] TesiraFORTÉ DAN with Shure MXA910 and/or MXA310 microphone arrays."); Exhibit O (Shure Q&A) (answering that customers can use QSC Qsys with MXA310). Shure thereby jointly infringes one or more claims of the '553 Patent, including claims 1, 8, and 15 of the '553 Patent, by conditioning the receipt of a benefit to the end user on performing the steps outlined in the '553 Patent. And Shure uses, offers to sell and/or sells in the United States, and/or imports into United States, the infringing integrated systems.

76. Shure has also induced and continues to induce infringement of one or more claims of the '553 Patent, including, without limitation, claims 1, 8, and 15 of the '553 Patent, by supplying, advertising and/or providing instructions for the infringing integrated systems with the specific intent that its customers infringe the '553 Patent despite knowledge that its customers' induced acts infringe the '553 Patent. Shure has also contributorily infringed and continues to contributorily infringe one or more claims of the '553 Patent, including, without limitation, claims 1, 8, and 15 of the '553 Patent, by, despite its knowledge of the '553 Patent, offering to sell and selling within the United States, or importing into the United States, material

components of the claimed invention in the ’553 Patent that have no substantial non-infringing use to Shure’s customers, knowing such components are especially made or adapted for use to infringe the ’553 Patent.

77. In addition, upon information and belief, Shure has supplied and continues to supply—from the United States to foreign countries—the individual components (including hardware, software, and firmware) of the MXA910, MXA310, and IntelliMix P300 which constitute all or a substantial portion of the components of the apparatus claimed in the ’553 Patent. Shure is inducing the combination of these individual components—into the apparatus claimed in the ’553 Patent—outside of the United States in at least Shure’s Juarez, Mexico manufacturing plant.

78. Upon information and belief, Shure has also supplied and continues to supply—from the United States to foreign countries including but not limited to China, Brazil, and Germany—the completed MXA910, MXA310, and IntelliMix P300, which individually constitute a substantial portion of the components of the ’553 Patent. Shure is inducing its customers into combining the MXA910 and MXA310 with the P300, Tesira/TesiraFORTE, or Q-SYS audio DSP mixers outside of the United States.

79. Shure is intending and inducing each of the aforementioned combinations despite its knowledge that these combinations would infringe the ’553 Patent if they occurred in the United States.

80. In addition, upon information and belief, Shure has supplied and continues to supply—from the United States to foreign countries including but not limited to China, Brazil, and Germany—the MXA910 and MXA310 microphones, despite knowing that it is not a staple article suitable for substantial noninfringing use, but is especially made or adapted for use in an

infringing combination with the P300, Tesira/TesiraFORTE, or Q-SYS. Shure is intending that the MXA910 and MXA310 be combined with the P300, Tesira/TesiraFORTE, or Q-SYS.

81. Shure is intending and inducing each of the aforementioned combinations despite its knowledge that these combinations would infringe the '553 Patent if they occurred in the United States.

82. Shure knew of the '921 Application, including after its issuance as the '553 Patent. Indeed, Shure filed litigation against ClearOne relating to the '553 Patent.

83. Shure's infringement is willful.

84. ClearOne has suffered and continues to suffer damages and irreparable harm because of Shure's past and ongoing infringement.

85. Unless Shure's infringement is enjoined, ClearOne will continue to be damaged and irreparably harmed. ClearOne meets the criteria for, and is entitled to, temporary, preliminary, and permanent injunctive relief.

COUNT II

Claim for Misappropriation of Trade Secrets
Under the Defend Trade Secrets Act (18 U.S.C. § 1836, et seq.)

86. ClearOne incorporates by reference paragraphs 1 through 72 and Exhibits A-R attached hereto.

87. ClearOne's highly confidential price lists constitute protectable trade secrets under the federal Defend Trade Secrets Act, codified at 18 U.S.C. § 1836 et seq. ("DTSA"). ClearOne's successful business is directly dependent upon maintaining the secrecy of its trade secrets and other confidential and proprietary information. ClearOne's nonpublic price lists for its products are business and economic information. The price lists derive independent economic value from being nonpublic because they provide ClearOne a competitive advantage in being

able to offer preferable pricing to sell its products. If the price lists were publicly available, ClearOne's competitors would be able to use the price lists to, among other things, undercut ClearOne and win sales and harm ClearOne's ability to maintain fair and orderly pricing among its channel partners.

88. ClearOne's highly confidential price lists are meant to be used to sell ClearOne's products throughout the United States and worldwide. Accordingly, ClearOne's trade secrets at issue are related to a product or service used in, or intended for use in, interstate commerce.

89. ClearOne takes reasonable measures to keep its highly confidential price lists confidential. For example, it includes broad confidentiality provisions in its contracts with manufacturer representatives, dealers, resellers, and distributors to ensure that they do not share the price lists outside of the ClearOne sales channel. Moreover, ClearOne routinely marks the dealer price lists "Confidential" to make it clear that the price lists are not meant to be shared outside of those with a need to know. ClearOne also restricts the dissemination of price lists both internally at ClearOne and externally to manufacturer representatives, dealers, resellers, and distributors. Only employees with express authorization of the Sr. Vice President of Finance and their manager are authorized access to the price lists and, even then, only the specific price lists they require. With respect to external persons, only those specific price lists are shared that will assist the manufacturer representatives, dealers, resellers, and distributors in selling ClearOne products and the e-mail transmittal of the price lists contains language making clear to the recipient that the communication and attachment are confidential.

90. [redacted]

[redacted]

91. [redacted]

92. [redacted] Shure's conduct caused ClearOne to lose sales that it would have otherwise not lost, if not for Shure's misappropriation.

93. As a proximate result of Shure's misappropriation, ClearOne has suffered, and will continue to suffer, actual damages, and Shure will be unjustly enriched, in sums not yet ascertained. ClearOne has also suffered and will continue to suffer immediate and irreparable harm, and will continue to suffer such injury until the breaches are preliminarily and permanently enjoined.

94. Shure's misappropriation was intentional, malicious, and in bad faith. It has

subjected and will continue to subject ClearOne to unjust hardship in conscious disregard of ClearOne's rights, so as to justify an award of exemplary and punitive damages according to proof at trial. Under the DTSA, ClearOne is entitled to recover its reasonable attorneys' fees as a result of Shure's willful and malicious misappropriation.

COUNT III

Claim for Misappropriation of Trade Secrets
Under the Illinois Trade Secrets Act (765 ILCS 1065)
(Against Shure)

95. ClearOne incorporates by reference paragraphs 1 through 72 and Exhibits A-R attached hereto.

96. ClearOne's highly confidential price lists constitute protectable trade secrets, as defined in the Illinois Trade Secrets Act ("ITSA") at 765 ILCS 1065/2(d). ClearOne's successful business is directly dependent upon maintaining the secrecy of its trade secrets and other confidential and proprietary information. ClearOne's nonpublic dealer price lists for its products are business and economic information. The price lists derive independent economic value from being nonpublic because they provide ClearOne a competitive advantage in being able to offer preferable pricing to sell its products. If the price lists were publicly available, ClearOne's competitors would be able to use the price lists to, among other things, undercut ClearOne and win sales and harm ClearOne's ability to maintain fair and orderly pricing among its channel partners.

97. ClearOne takes reasonable measures to keep its price lists highly confidential. For example, it includes broad confidentiality provisions in its contracts with manufacturer representatives, dealers, resellers, and distributors to ensure that they do not share the price lists outside of the ClearOne sales channel. Moreover, ClearOne routinely marks the dealer price lists

"Confidential" to make it clear that the price lists are not meant to be shared publicly. ClearOne also restricts the dissemination of price lists both internally at ClearOne and externally to manufacturer representatives, dealers, resellers, and distributors. Only employees with express authorization of the Sr. Vice President of Finance and their manager are authorized access to the price lists and, even then, only the specific price lists they require. With respect to external persons, only those specific price lists are shared that will assist the manufacturer representatives, dealers, resellers, and distributors in selling ClearOne products and the e-mail transmittal of the price lists contains language making clear to the recipient that the communication and attachment are confidential.

98. [redacted]

99. [redacted]

[redacted]

100. [redacted] Shure's conduct caused ClearOne to lose sales that it would have otherwise not lost, if not for Shure's misappropriation.

101. [redacted]

102. As a proximate result of Shure's misappropriation, ClearOne has suffered, and will continue to suffer, actual damages, and Shure will be unjustly enriched, in sums not yet ascertained. ClearOne has also suffered and will continue to suffer immediate and irreparable harm and will continue to suffer such injury until the breaches are preliminarily and permanently enjoined.

103. Shure's misappropriation was intentional, malicious, and in bad faith. It has subjected and will continue to subject ClearOne to unjust hardship in conscious disregard of ClearOne's rights, so as to justify an award of exemplary and punitive damages according to proof at trial. Under the ITSA, ClearOne is entitled to recover its reasonable attorneys' fees as a result of Shure's willful and malicious misappropriation.

COUNT IV

Tortious Interference with Prospective Economic Advantage (Against Shure)

104. ClearOne incorporates by reference paragraphs 1 through 72 and Exhibits A-R attached hereto.

105. ClearOne has a reasonable expectation of entering into valid business relationships with integrators, consultants, customers, and other third parties that it transmitted the Narayanan Letter to. ClearOne believed that the PI Order would help it gain additional business by bolstering its argument that it offers the only patented ceiling tile beamforming microphone array that can be placed in a drop-ceiling mounting configuration. ClearOne believed that sending the Narayanan Letter would inform market participants of the strength and validity of its positions and make it more likely that the market participants would choose the ClearOne BMA-CT product to solve their audio-conferencing needs.

106. Shure knew of the Narayanan Letter, as evidenced by its references to the Narayanan Letter in its September 4, 2019, message to market participants. Upon information and belief, Shure also knew that ClearOne sent the Narayanan Letter in order to inform market participants of the validity of its positions and make it more likely that the market participants would choose the ClearOne BMA-CT product to solve their audio-conferencing needs.

107. Shure wrongly claimed in its September 4, 2019, message to market participants that ClearOne made "false statements" in the Narayanan Letter. Shure's false claim defamed ClearOne in a way that interfered with ClearOne's business expectancy and prevented ClearOne from realizing its legitimate expectancy from ripening into valid business relationships.

108. ClearOne was damaged by Shure's false statement because, upon information and belief, market participants that would have done business with ClearOne decided not to do

business with ClearOne because Shure falsely claimed that ClearOne was making false statements. Indeed, the morning after Shure sent its message, one such market participant vowed never to do business with ClearOne again.

109. Shure's false statements caused ClearOne to suffer money damages, loss of goodwill, and loss of reputation. ClearOne is also entitled to recover punitive damages due to Shure's malice and willfulness in making the false statements against ClearOne. Upon information and belief, Monster ClearOne also requests that Shure be enjoined from making any further similar false statements about ClearOne to market participants.

COUNT V

Trade Libel
(Against Shure)

110. ClearOne incorporates by reference paragraphs 1 through 72 and Exhibits A-R attached hereto.

111. ClearOne transmitted the Narayanan Letter to integrators, consultants, customers, and other third parties that it conducts business with, or seeks to conduct business with. ClearOne believed that the PI Order would help it gain additional business by bolstering its argument that it offers the only patented ceiling tile beamforming microphone array that can be placed in a drop-ceiling mounting configuration. ClearOne believed that sending the Narayanan Letter would inform market participants of the strength and validity of its positions and make it more likely that the market participants would choose the ClearOne BMA-CT product to solve their audio-conferencing needs.

112. Shure knew of the Narayanan Letter, as evidenced by its references to the Narayanan Letter in its September 4, 2019, message to market participants. Upon information and belief, Shure also knew that ClearOne sent the Narayanan Letter in order to inform market

participants of the validity of its positions and make it more likely that the market participants would choose the ClearOne BMA-CT product to solve their audio-conferencing needs.

113. Shure wrongly claimed in its September 4, 2019, message to market participants that ClearOne made "false statements" in the Narayanan Letter. Shure's message to market participants constitutes an unprivileged publication to third parties.

114. Shure made the false statement with actual malice, as it knew that its statement was false or had a reckless disregard for its veracity, and yet still transmitted it to market participants.

115. Shure's false claim constitutes libel *per* se because it improperly impugns ClearOne's integrity and abilities in its business and trade.

116. ClearOne was damaged by Shure's false statement because, upon information and belief, market participants that would have done business with ClearOne decided not to do business with ClearOne because Shure falsely claimed that ClearOne was making false statements. Indeed, the morning after Shure sent its message, one such market participant vowed never to do business with ClearOne again.

117. Shure's false statements caused ClearOne to suffer money damages, loss of goodwill, and loss of reputation. ClearOne is also entitled to recover punitive damages due to Shure's malice and willfulness (or gross negligence) in making the false statements against ClearOne. ClearOne also requests that Shure be enjoined from making any further similar false statements about ClearOne to market participants.

PRAYER FOR RELIEF

WHEREFORE, ClearOne respectfully asks that the Court enter judgment against Shure as follows:

A. That Shure has infringed (either literally or under the doctrine of equivalents), directly, jointly, and/or indirectly by way of inducing or contributing to the infringement of, one or more claims of ClearOne's '553 Patent;

B. That Shure's infringement of the '553 Patent was willful;

C. For temporary, preliminary, and permanent injunctive relief enjoining Shure and its officers, directors, agents, affiliates, employees, divisions, branches, subsidiaries, parents, and all others acting in active concert or participation with it, from infringement, inducing the infringement, or contributing to the infringement of the '553 Patent;

D. For an award to ClearOne for its damages, costs, expenses, and prejudgment and post-judgment interest for Shure's infringement of the '553 Patent as provided under 35 U.S.C. §§ 154(d) and 284;

E. For an award to ClearOne for enhanced damages equal to treble the amount of actual damages, for the willful nature of Shure's acts of infringement as to the '553 Patent, with notice being made at least as early as the date of the filing of the complaint, as provided under 35 U.S.C. § 284;

F. That this be declared an exceptional case within the meaning of 35 U.S.C. § 285 and that ClearOne be awarded its reasonable attorneys' fees against Shure;

G. That Shure has misappropriated ClearOne's trade secrets under the DTSA, 18 U.S.C. § 1836, and ITSA, 765 ILCS 1065;

H. For an award of actual loss, unjust enrichment, and/or reasonable royalty under the DTSA, 18 U.S.C. § 1836(b)(3), and ITSA, 765 ILCS 1065/4;

I. For injunctive relief and/or an imposition of a reasonable royalty as compensation

for future use, under the DTSA, 18 U.S.C. § 1836(b)(3), and ITSA, 765 ILCS 1065/3;

J. For an award of reasonable attorney's fees under the DTSA, 18 U.S.C. § 1836(b)(3)(D), and ITSA, 765 ILCS 1065/5;

K. For an award of compensatory damages of at least $75,000 and punitive damages under the torts of tortious interference with prospective economic advantage and trade libel; and

L. For injunctive relief preventing Shure from making any further similar false statements about ClearOne.

For any and all other relief to which ClearOne may show itself to be entitled.

Dated: December 16, 2019

By: */s/ Douglas J. Dixon*

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EXHIBIT A

US009264553B2

(12) **United States Patent**
Pandey et al.

(10) **Patent No.: US 9,264,553 B2**
(45) **Date of Patent: Feb. 16, 2016**

(54) **METHODS AND APPARATUSES FOR ECHO CANCELATION WITH BEAMFORMING MICROPHONE ARRAYS**

(75) Inventors: **Ashutosh Pandey**, Murray, UT (US); **Darrin T. Thurston**, Liberty, UT (US); **David K. Lambert**, South Jordan, UT (US); **Tracy A. Bathurst**, South Jordan, UT (US)

(73) Assignee: **ClearOne Communications, Inc.**, Salt Lake City, UT (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 723 days.

(21) Appl. No.: **13/493,921**

(22) Filed: **Jun. 11, 2012**

(65) **Prior Publication Data**

US 2013/0039504 A1 Feb. 14, 2013

Related U.S. Application Data

(60) Provisional application No. 61/495,961, filed on Jun. 11, 2011, provisional application No. 61/495,968, filed on Jun. 11, 2011, provisional application No. 61/495,971, filed on Jun. 11, 2011.

(51) **Int. Cl.**

H04B 3/20	(2006.01)
H04M 9/08	(2006.01)
H04B 15/00	(2006.01)

(52) **U.S. Cl.**

CPC ***H04M 9/082*** (2013.01)

(58) **Field of Classification Search**

CPC H04R 3/005; H04R 2430/20; H04R 1/406; H04M 9/082; H04M 9/08

USPC 381/66, 71.1, 93; 379/406.01–406.16; 348/14.01

See application file for complete search history.

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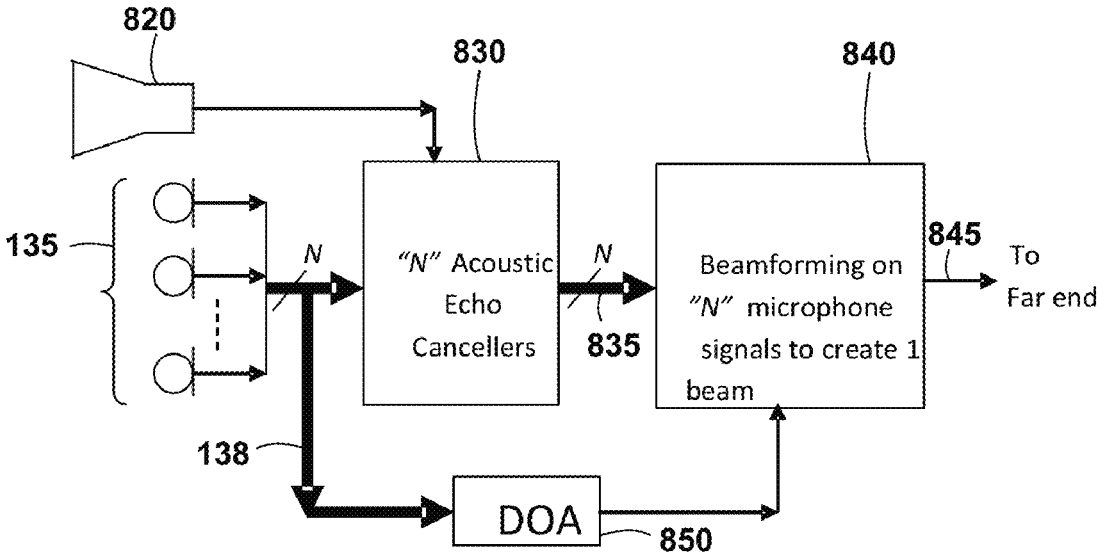
* cited by examiner

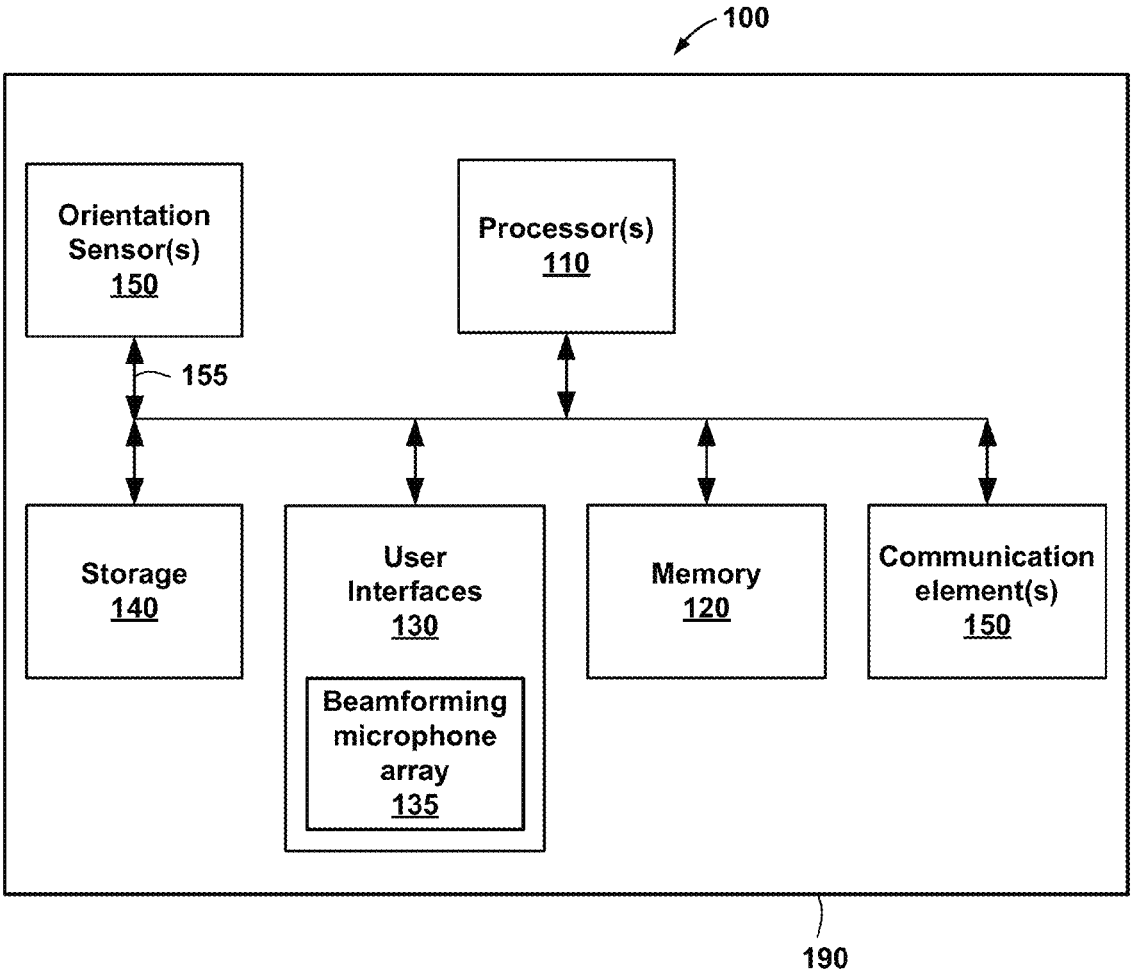
Primary Examiner — Vivian Chin
Assistant Examiner — Ammar Hamid
(74) *Attorney, Agent, or Firm* — TraskBritt

(57) **ABSTRACT**

Embodiments include methods and apparatuses for sensing acoustic waves for a conferencing application. A conferencing apparatus includes a plurality of microphones oriented to cover a corresponding plurality of direction vectors and to develop a corresponding plurality of microphone signals. A processor is operably coupled to the plurality of microphones. The processor is configured to perform a beamforming operation to combine the plurality of microphone signals to a plurality of combined signals that is greater in number than one and less in number than the plurality of microphone signals. The processor is also configured perform an acoustic echo cancelation operation on the plurality of combined signals to generate a plurality of combined echo-canceled signals and select one of the plurality of combined echo-canceled signals for transmission.

20 Claims, 10 Drawing Sheets

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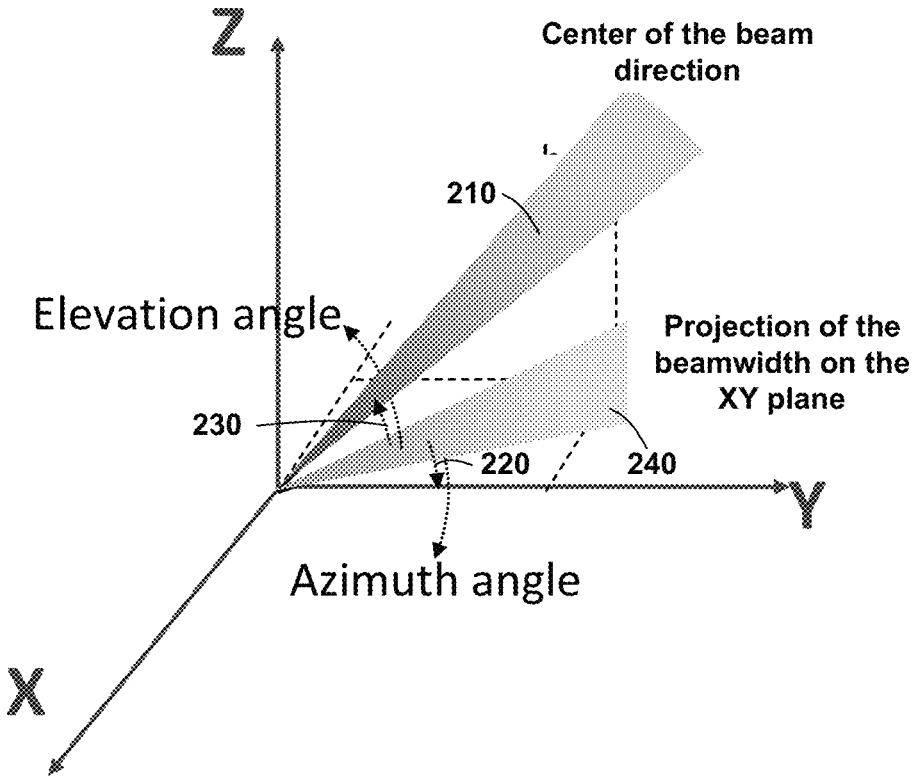
Processor(s) 110
155
Storage 140
User Interfaces 130
Beamforming microphone array 135
Memory 120
Communication element(s) 150
190

FIG. 1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Center of the beam direction
210
Elevation angle
Projection of the beamwidth on the XY plane
230
220
240
Y
Azimuth angle
X

FIG. 2

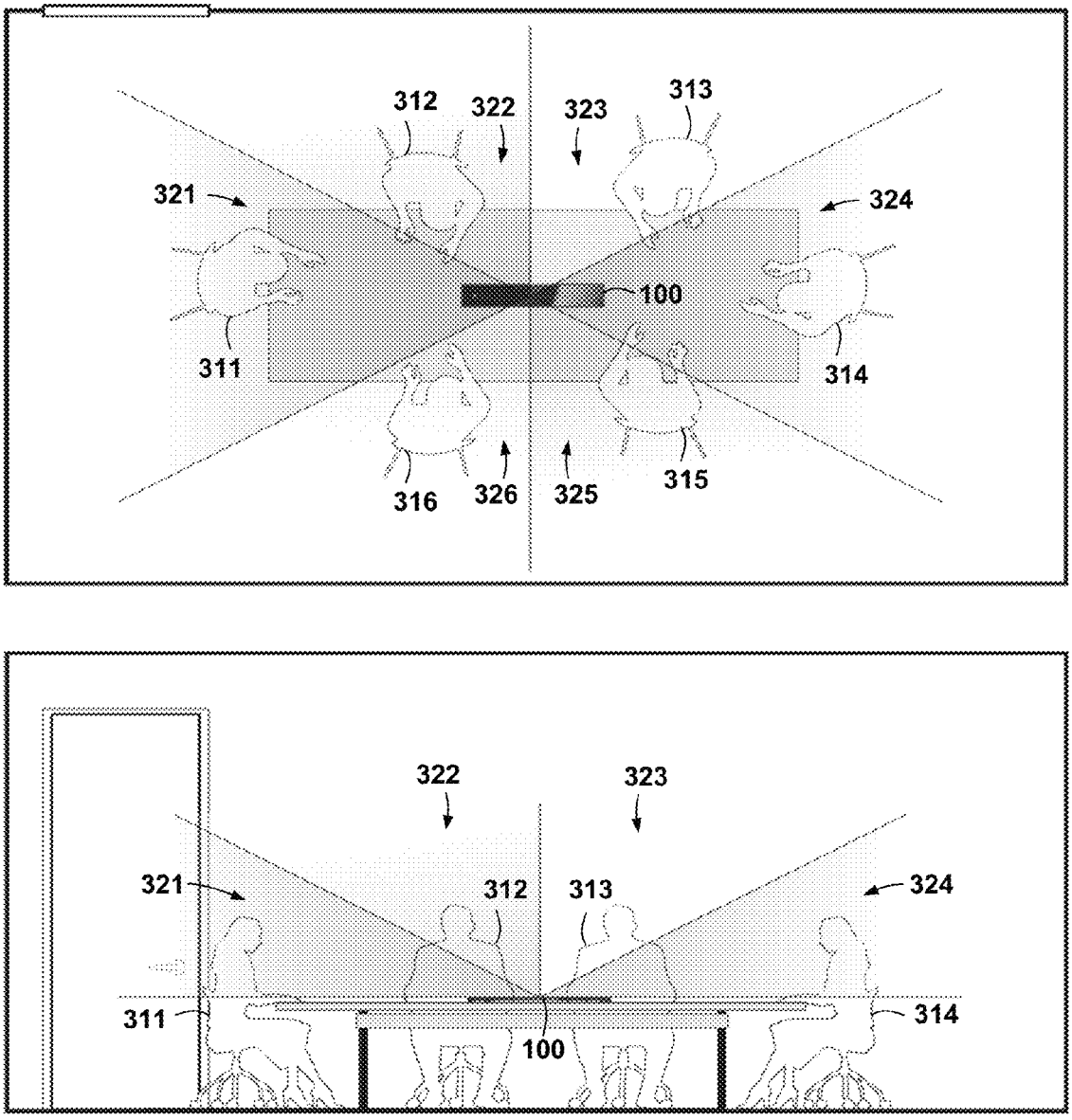
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FIG. 3

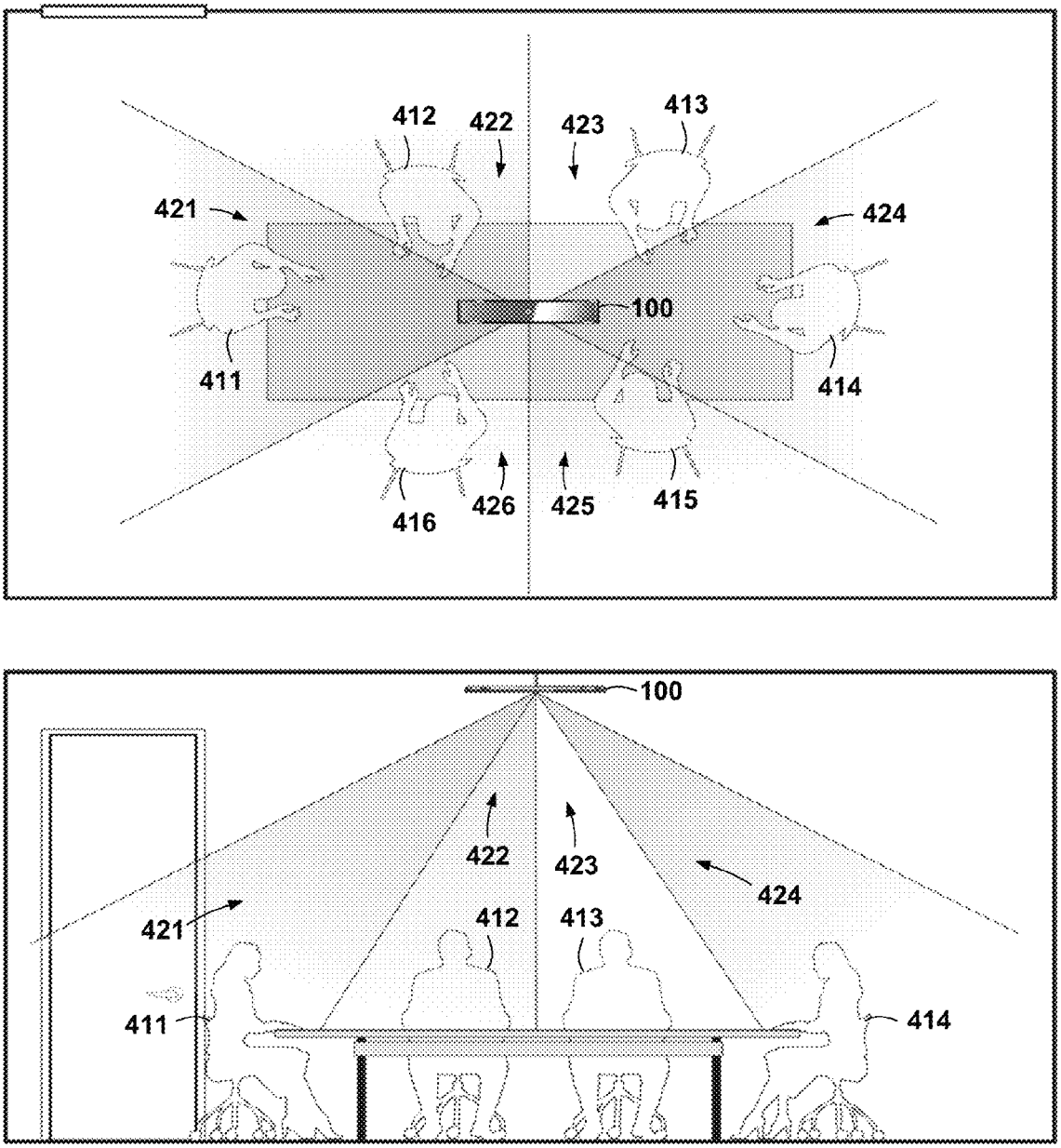
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FIG. 4

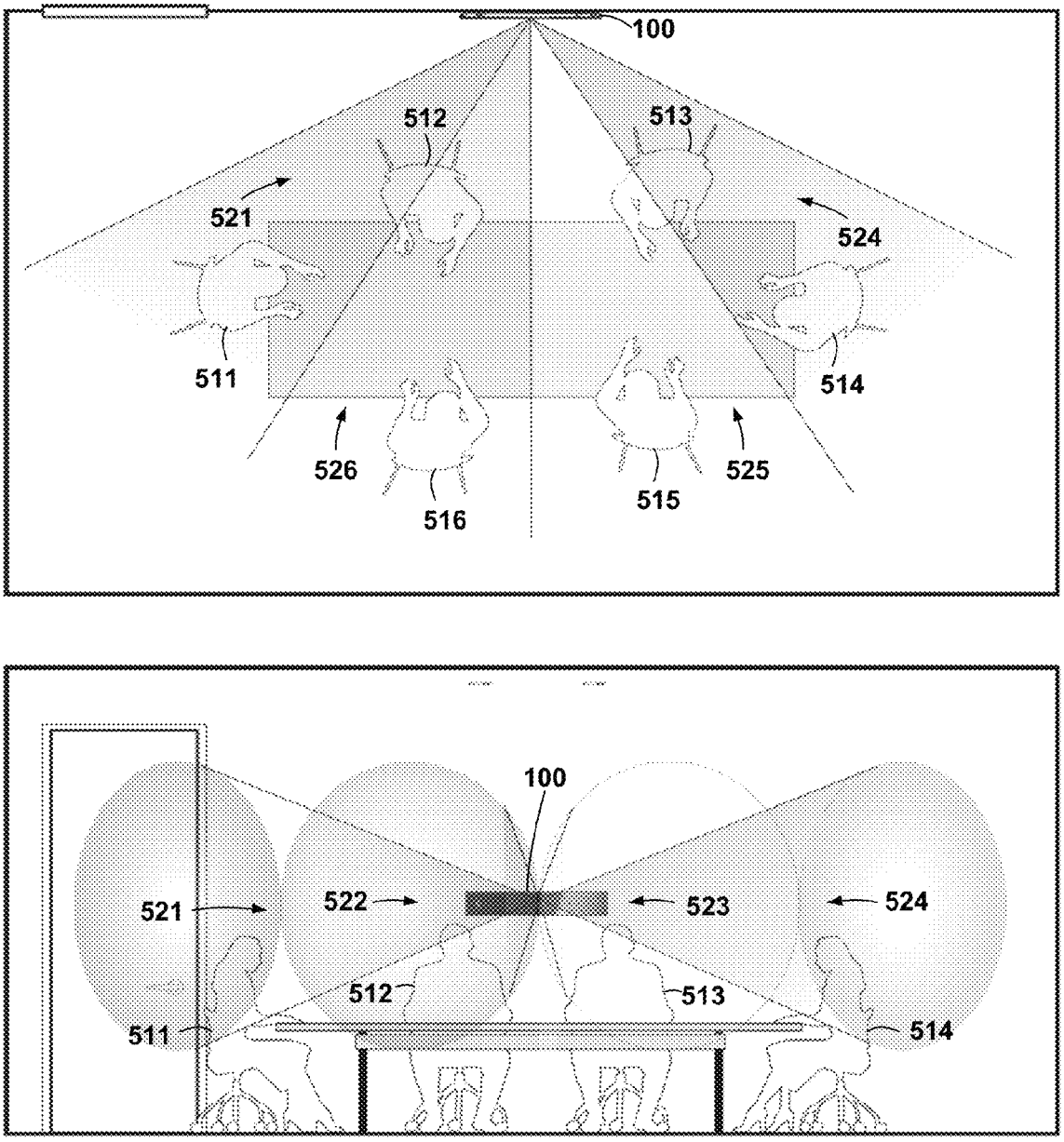
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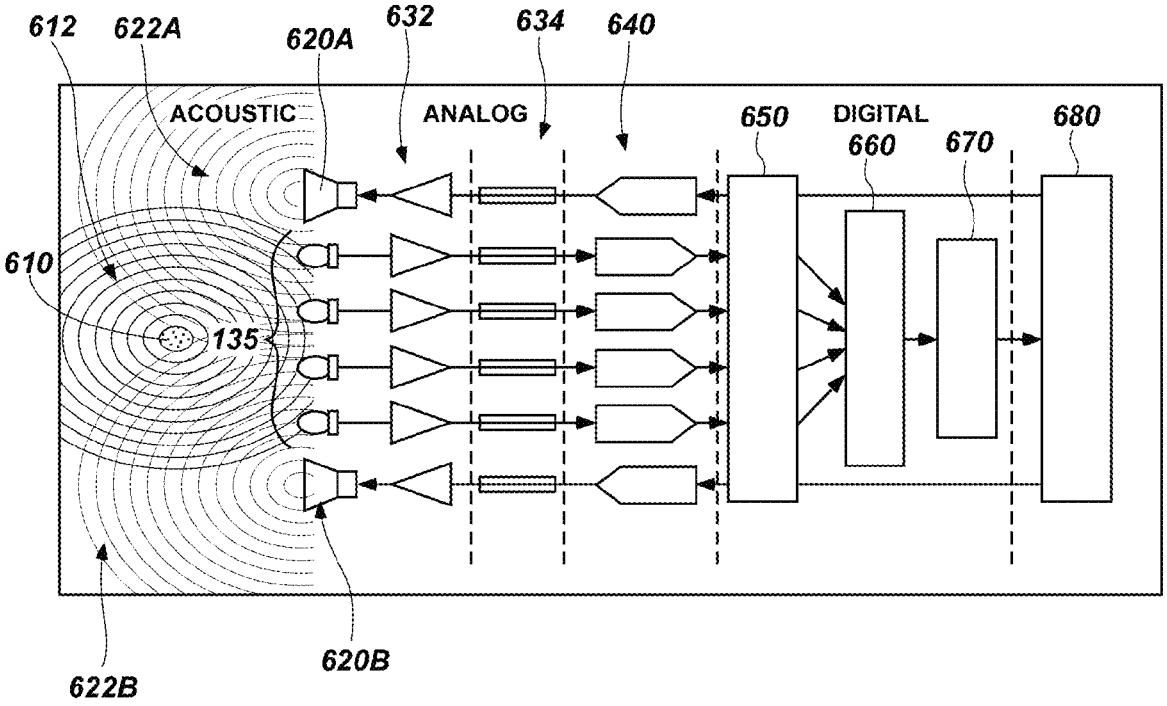
FIG. 5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622A
620A
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634
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ANALOG
650
DIGITAL
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670
680
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135
622B
620B

FIG. 6

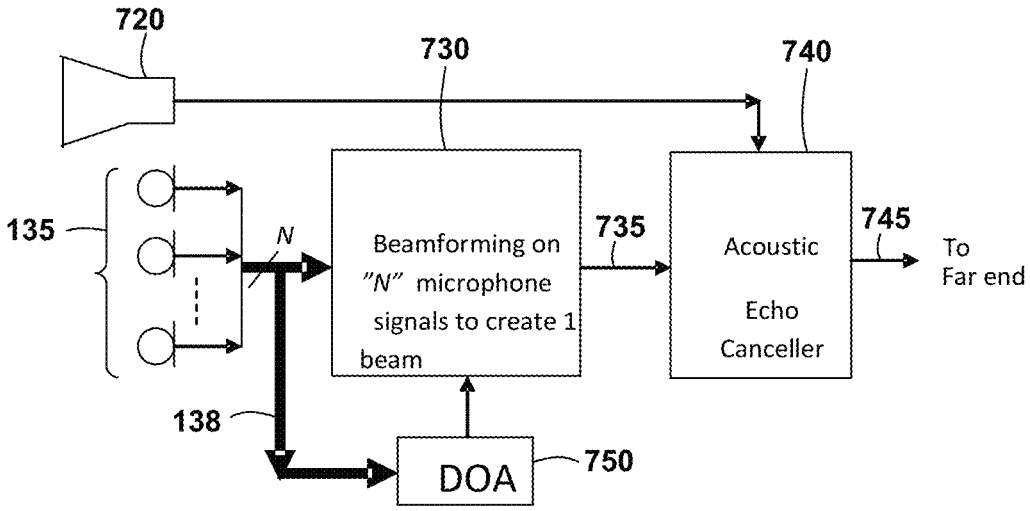

720
730
740
135
N
Beamforming on "N" microphone signals to create 1 beam
735
Acoustic Echo Canceller
745
To Far end
138
DOA
750

FIG. 7

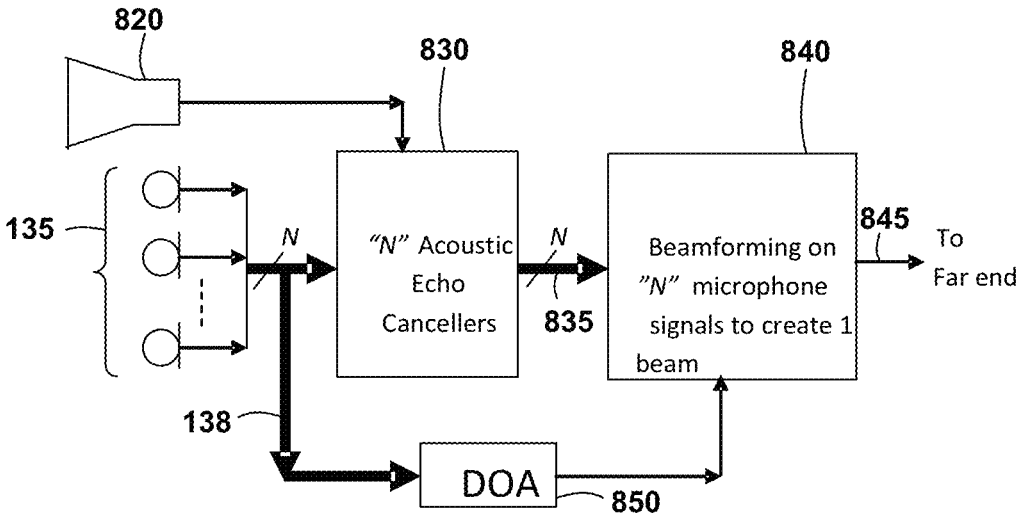

820
830
840
135
N
"N" Acoustic Echo Cancellers
N
835
Beamforming on "N" microphone signals to create 1 beam
845
To Far end
138
DOA
850

FIG. 8

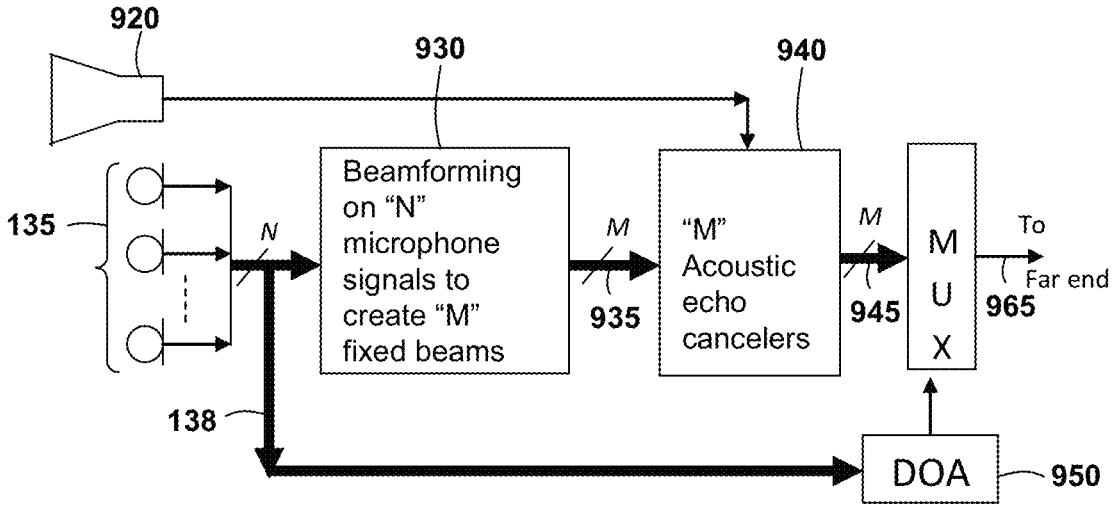

920
930
940
135
N
Beamforming on "N" microphone signals to create "M" fixed beams
M
935
"M" Acoustic echo cancelers
M
945
M U X
To
Far end
965
138
DOA
950

FIG. 9

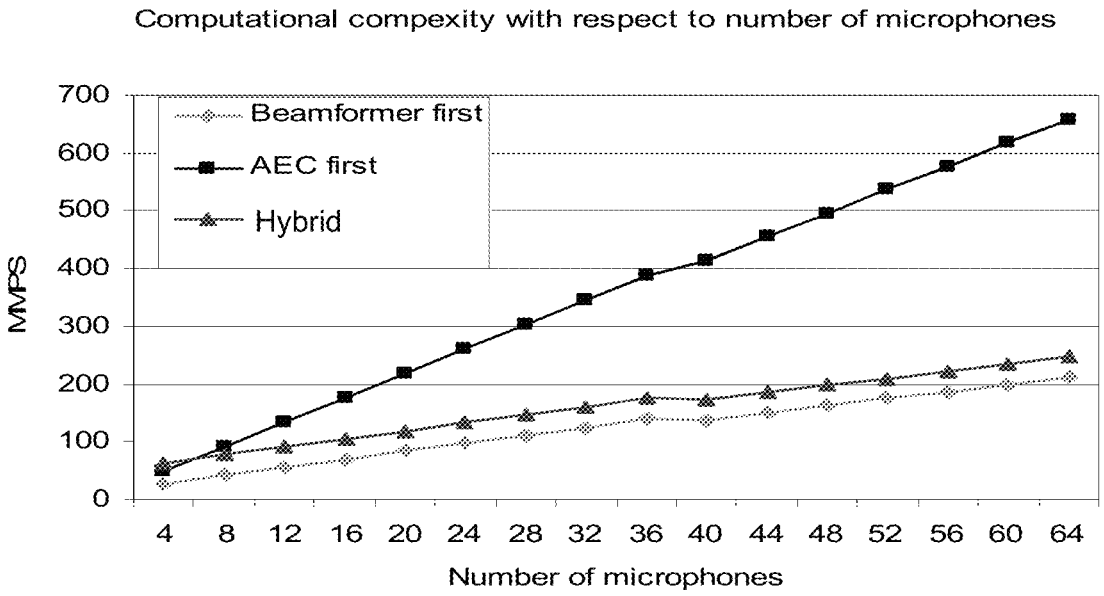

Computational compexity with respect to number of microphones
Beamformer first
AEC first
Hybrid
MMPS
700
600
500
400
300
200
100
0
4
8
12
16
20
24
28
32
36
40
44
48
52
56
60
64
Number of microphones

FIG. 10

METHODS AND APPARATUSES FOR ECHO CANCELATION WITH BEAMFORMING MICROPHONE ARRAYS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of: U.S. Provisional Patent Application Ser. No. 61/495,971, filed Jun. 11, 2011 and entitled "Beamforming Microphone Array for Telepresence Application," U.S. Provisional Patent Application Ser. No. 61/495,961, filed Jun. 11, 2011 and entitled "Combining a Beamforming Microphone Array With an Acoustic Echo Canceller for Teleconferencing Applications," and U.S. Provisional Patent Application Ser. No. 61/495,968, filed Jun. 11, 2011 and entitled "Combining a Beamforming Microphone Array With an Acoustic Echo Canceller for Teleconferencing Applications," the disclosures of each of which are incorporated herein in their entirety by this reference.

TECHNICAL FIELD

Embodiments of the present disclosure relate generally to methods and apparatuses for beamforming microphone arrays. More specifically, embodiments of the present disclosure relate to methods and apparatuses with echo cancelation in beamforming microphone arrays.

BACKGROUND

In a typical telepresence application, such as, for example, teleconferencing, a loudspeaker may be located on top, bottom or side of a television set, a microphone may be located in line with the television set and a participant sits in line with a television for the audio conferencing part of it.

Many improvements have been made in teleconferencing and video conferencing systems, which may use microprocessors and software to accomplish a wide variety of system tasks and signal processing algorithms to improve on, compress, and even encrypt video and audio streams. Some teleconferencing applications may include multiple microphones in an array to better capture acoustic patterns of a room and the participants in the room. However, arrayed microphones can cause their own problems with duplicate coverage and echoing.

There is a need for methods and apparatuses to improve on the acoustic quality of microphone arrays with echo cancelation and a need to perform this echo cancelation efficiently.

BRIEF SUMMARY

Embodiments of the present disclosure include methods and apparatuses to improve the acoustic quality of microphone arrays with echo cancelation and perform this echo cancelation efficiently.

Embodiments of the present disclosure include a method of echo cancellation for a conferencing application. The method includes sensing acoustic waves with a plurality of microphones to develop a corresponding plurality of microphone signals. A beamforming operation is performed to combine the plurality of microphone signals to a plurality of combined signals that is greater in number than one and less in number than the plurality of microphone signals. An acoustic echo cancelation operation is performed on the plurality of combined signals to generate a plurality of combined echo-canceled signals and one or more of the plurality of combined echo-canceled signals is selected for transmission.

Embodiments of the present disclosure include a conferencing apparatus. A plurality of microphones are oriented to cover a plurality of direction vectors and to develop a corresponding plurality of microphone signals. A processor is operably coupled to the plurality of microphones. The processor is configured to perform a beamforming operation to combine the plurality of microphone signals to a plurality of combined signals that is greater in number than one and less in number than the plurality of microphone signals. The processor is also configured perform an acoustic echo cancelation operation on the plurality of combined signals to generate a plurality of combined echo-canceled signals and select one or more of the plurality of combined echo-canceled signals for transmission.

Embodiments of the present disclosure include a conferencing apparatus with a beamforming microphone array. Each microphone of the beamforming microphone array is configured to sense acoustic waves from a direction vector substantially different from other microphones in the beamforming microphone array. A memory is configured for storing computing instructions. A processor is operably coupled to the beamforming microphone array and the memory. The processor is configured to execute the computing instructions to perform a beamforming operation to combine the plurality of microphone signals to a plurality of combined signals that includes a number of signals between one and a number of signals in the plurality of microphone signals. The processor is also configured to execute the computing instructions to perform an acoustic echo cancelation operation on the plurality of combined signals to generate a plurality of combined echo-canceled signals.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. **1** is a block diagram illustrating a conferencing apparatus according to one or more embodiments of the present disclosure;

FIG. **2** illustrates geometrical representations of a beam for a microphone;

FIG. **3** illustrates a top view and a side view of a conference room including participants and a conferencing apparatus disposed on a table and illustrating beams that may be formed by a beamforming microphone array disposed in the conferencing apparatus;

FIG. **4** illustrates a top view and a side view of a conference room including participants and a conferencing apparatus depending from a ceiling and illustrating beams that may be formed by a beamforming microphone array disposed in the conferencing apparatus;

FIG. **5** illustrates a top view and a side view of a conference room including participants and a conferencing apparatus disposed on a wall and illustrating beams that may be formed by a beamforming microphone array disposed in the conferencing apparatus;

FIG. **6** illustrates elements involved in sensing acoustic waves with a plurality of microphones and signal processing that may be performed on the sensed acoustic waves;

FIG. **7** illustrates processing involved in sensing acoustic waves wherein signals from all of the microphones are combined, then acoustic echo cancelation is performed on the combined signal to create a combined echo canceled signal;

FIG. **8** illustrates processing involved in sensing acoustic waves wherein acoustic echo cancelation is performed on signals from each of the microphones, then the echo canceled signals are combined, to create a combined echo canceled signal;

FIG. **9** illustrates processing involved in sensing acoustic waves wherein a subset of signals from the microphones are combined, then acoustic echo cancelation is performed one or more of the combined signals; and

FIG. **10** illustrates computational complexity of various embodiments relative to number of microphones in a beamforming microphone array.

DETAILED DESCRIPTION

In the following description, reference is made to the accompanying drawings in which is shown, by way of illustration, specific embodiments of the present disclosure. The embodiments are intended to describe aspects of the disclosure in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments may be utilized and changes may be made without departing from the scope of the disclosure. The following detailed description is not to be taken in a limiting sense, and the scope of the present invention is defined only by the appended claims.

Furthermore, specific implementations shown and described are only examples and should not be construed as the only way to implement or partition the present disclosure into functional elements unless specified otherwise herein. It will be readily apparent to one of ordinary skill in the art that the various embodiments of the present disclosure may be practiced by numerous other partitioning solutions.

In the following description, elements, circuits, and functions may be shown in block diagram form in order not to obscure the present disclosure in unnecessary detail. Additionally, block definitions and partitioning of logic between various blocks is exemplary of a specific implementation. It will be readily apparent to one of ordinary skill in the art that the present disclosure may be practiced by numerous other partitioning solutions. Those of ordinary skill in the art would understand that information and signals may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof. Some drawings may illustrate signals as a single signal for clarity of presentation and description. It will be understood by a person of ordinary skill in the art that the signal may represent a bus of signals, wherein the bus may have a variety of bit widths and the present disclosure may be implemented on any number of data signals including a single data signal.

The various illustrative logical blocks, modules, and circuits described in connection with the embodiments disclosed herein may be implemented or performed with a general-purpose processor, a special-purpose processor, a Digital Signal Processor (DSP), an Application Specific Integrated Circuit (ASIC), a Field Programmable Gate Array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A general-purpose processor may be considered a special-purpose processor while the general-purpose processor is configured to execute instructions (e.g., software code) stored on a computer-readable medium. A processor may also be implemented as a combination of computing devices, such as a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

In addition, it is noted that the embodiments may be described in terms of a process that may be depicted as a flowchart, a flow diagram, a structure diagram, or a block diagram. Although a process may describe operational acts as a sequential process, many of these acts can be performed in another sequence, in parallel, or substantially concurrently. In addition, the order of the acts may be rearranged.

Elements described herein may include multiple instances of the same element. These elements may be generically indicated by a numerical designator (e.g. **110**) and specifically indicated by the numerical indicator followed by an alphabetic designator (e.g., **110**A) or a numeric indicator preceded by a "dash" (e.g., **110-1**). For ease of following the description, for the most part element number indicators begin with the number of the drawing on which the elements are introduced or most fully discussed. For example, where feasible elements in FIG. **3** are designated with a format of **3***xx*, where **3** indicates FIG. **3** and xx designates the unique element.

It should be understood that any reference to an element herein using a designation such as "first," "second," and so forth does not limit the quantity or order of those elements, unless such limitation is explicitly stated. Rather, these designations may be used herein as a convenient method of distinguishing between two or more elements or instances of an element. Thus, a reference to first and second elements does not mean that only two elements may be employed or that the first element must precede the second element in some manner. In addition, unless stated otherwise, a set of elements may comprise one or more elements.

Embodiments of the present disclosure include methods and apparatuses to improve the acoustic quality of microphone arrays with echo cancelation and to perform this echo cancelation efficiently.

FIG. **1** illustrates a conferencing apparatus **100** for practicing embodiments of the present disclosure. The conferencing apparatus **100** may include elements for executing software applications as part of embodiments of the present disclosure. Thus, the system **100** is configured for executing software programs containing computing instructions and includes one or more processors **110**, memory **120**, one or more communication elements **150**, and user interface elements **130**. The system **100** may also include storage **140**. The conferencing apparatus **100** may be included in a housing **190**.

The one or more processors **110** may be configured for executing a wide variety of applications including the computing instructions for carrying out embodiments of the present disclosure.

The memory **120** may be used to hold computing instructions, data, and other information for performing a wide variety of tasks including performing embodiments of the present disclosure. By way of example, and not limitation, the memory **120** may include Synchronous Random Access Memory (SRAM), Dynamic RAM (DRAM), Read-Only Memory (ROM), Flash memory, and the like.

Information related to the system **100** may be presented to, and received from, a user with one or more user interface elements **130**. As non-limiting examples, the user interface elements **130** may include elements such as displays, keyboards, mice, joysticks, haptic devices, microphones, speakers, cameras, and touchscreens.

The communication elements **150** may be configured for communicating with other devices or communication networks. As non-limiting examples, the communication elements **150** may include elements for communicating on wired

and wireless communication media, such as for example, serial ports, parallel ports, Ethernet connections, universal serial bus (USB) connections IEEE 1394 ("firewire") connections, Bluetooth wireless connections, 802.1 a/b/g/n type wireless connections, and other suitable communication interfaces and protocols.

The storage **140** may be used for storing relatively large amounts of non-volatile information for use in the computing system **100** and may be configured as one or more storage devices. By way of example, and not limitation, these storage devices may include computer-readable media (CRM). This CRM may include, but is not limited to, magnetic and optical storage devices such as disk drives, magnetic tapes, CDs (compact disks), DVDs (digital versatile discs or digital video discs), and other equivalent storage devices.

Software processes illustrated herein are intended to illustrate representative processes that may be performed by the systems illustrated herein. Unless specified otherwise, the order in which the process acts are described is not intended to be construed as a limitation, and acts described as occurring sequentially may occur in a different sequence, or in one or more parallel process streams. It will be appreciated by those of ordinary skill in the art that many steps and processes may occur in addition to those outlined in flow charts. Furthermore, the processes may be implemented in any suitable hardware, software, firmware, or combinations thereof.

When executed as firmware or software, the instructions for performing the processes may be stored on a computer-readable medium. A computer-readable medium includes, but is not limited to, magnetic and optical storage devices such as disk drives, magnetic tape, CDs (compact disks), DVDs (digital versatile discs or digital video discs), and semiconductor devices such as RAM, DRAM, ROM, EPROM, and Flash memory.

By way of non-limiting example, computing instructions for performing the processes may be stored on the storage **140**, transferred to the memory **120** for execution, and executed by the processors **110**. The processor **110**, when executing computing instructions configured for performing the processes, constitutes structure for performing the processes and can be considered a special-purpose computer when so configured. In addition, some or all portions of the processes may be performed by hardware specifically configured for carrying out the processes.

In some embodiments, an orientation sensor **150** may be included. As a non-limiting example, accelerometers configured to sense acceleration in at least two substantially orthogonal directions may be used. As another non-limiting example, a multi-axis accelerometer may be used. Of course, other types of position sensors may also be used, such as for example magnetometers to sense magnetic fields of the Earth.

Single- and multi-axis models of accelerometers may be used to detect magnitude and direction of the proper acceleration (i.e., g-force), and can be used to sense orientation. Orientation can be sensed because gravity acting on the accelerometers can detect direction of weight changes. The proper acceleration measured by an accelerometer is the acceleration associated with the phenomenon of weight experienced by any mass at rest in the frame of reference of the accelerometer device. For example, an accelerometer can measure a value of "g" in the upward direction when remaining stationary on the ground, because masses on the Earth have weight (i.e., mass*g). Another way of stating this phenomenon is that by measuring weight, an accelerometer measures the acceleration of the free-fall reference frame (i.e., the inertial reference frame) relative to itself.

One particular type of user interface element **130** used in embodiments of the present disclosure is a plurality of microphones **135**, which can be configured as a beamforming microphone array **135**.

Thus, accelerometers mounted in the housing **190** can be used to determine the orientation of the housing **190**. With the beamforming microphone array **135** also mounted in the housing **190**, the orientation of the beamforming microphone array **135** is easily determined because it is in a fixed position relative to the housing.

Microphones are often used in a teleconference to capture participant's audio. In a teleconference, microphones are usually placed on a table or hanged from ceiling and are manually positioned so that a participant audio is in the pick-up pattern of the microphone. Since, pick-up patterns of these microphones are fixed, more often than not one type of microphone, say a tabletop microphone, may not work for another type of installation, say a ceiling installation. Thus, an installer may need to know the type of installation (e.g., tabletop or ceiling), angle of participant's relative to the microphones, and the number of participants before installing a correct set of microphones.

In some embodiments of the present disclosure, the conferencing apparatus **100** uses a beamforming microphone array **135** that can be installed in a number of positions and configuration and beams for the microphones can be adjusted with base level configurations or automatically and adaptively bring participants into the pick-up pattern of the beamforming microphone array **135** based on the orientation and placement of the conferencing apparatus **100**.

Microphones may be used in conferencing applications to perform spatial filtering to improve audio quality. These microphones have a beam pattern that selectively picks up acoustic waves in a region of space and rejects others.

FIG. **2** illustrates geometrical representations of a beam for a microphone. A direction vector **210** of the beam extends from the microphone. The beam pattern for a microphone is usually specified with an azimuth angle **220**, an elevation angle **230**, and a beamwidth **240**. Of course, the beamwidth **240** will have a three-dimensional quality to it and FIG. **2** illustrates a projection of the beam width **240** onto the X-Y plane. Not only should a participant face a microphone, the location of the participant's mouth relative to the microphone should be in the beam pattern as well for good quality of the participant's audio.

Beamforming is a signal processing technique carried out by the processor **110** using input from the beamforming microphone array **135**. Various signal-processing characteristics of each of the microphones in the beamforming microphone array **135** may be modified. The signals from the various microphones may be combined such that that signals at particular angles experience constructive interference while others experience destructive interference. Thus, beamforming can be used to achieve spatial selectivity such that certain regions can be emphasized (i.e., amplified) and other regions can be de-emphasized (i.e., attenuated). As a non-limiting example, the beam-forming processing may be configured to attenuate sounds that originate from the direction of a door to a room.

Beamforming may use interference patterns to change the directionality of the array. In other words, information from the different microphones may be combined in a way where the expected pattern of radiation is preferentially observed. Beamforming techniques may involve combining delayed signals from each microphone at slightly different times so that every signal reaches the output at substantially the same time.

Moreover, signals from each microphone may be amplified by a different amount. Different weighting patterns may be used to achieve the desired sensitivity patterns. As a non-limiting example, a main lobe may be produced together with nulls and sidelobes. As well as controlling the main lobe width (the beam) and the sidelobe levels, the position of a null can be controlled. This is useful to ignore noise in one particular direction, while listening for events in other directions. Adaptive beamforming algorithms may be included to automatically adapt to different situations.

Embodiments of the present disclosure include a beamforming microphone array, where elevation angle of the beam can be programmed with software default settings or automatically adapted for an application. In some embodiments, various configurations for the conferencing apparatus, such as tabletop, ceiling, and wall configurations can be automatically identified with the orientation sensor **150** in the conferencing apparatus **100**.

FIG. **3** illustrates a top view and a side view of a conference room including participants and a conferencing apparatus **100** disposed on a table and illustrating beams that may be formed by a beamforming microphone array **135** disposed in the conferencing apparatus **100**. Beams **321**, **322**, **323**, **324**, **325**, and **326** can be configured with direction, beamwidth, amplification levels, and interference patterns to obtain quality coverage of participants, **311**, **312**, **313**, **314**, **315**, and **316**, respectively.

FIG. **4** illustrates a top view and a side view of a conference room including participants and a conferencing apparatus **100** depending from a ceiling and illustrating beams that may be formed by a beamforming microphone array **135** disposed in the conferencing apparatus. Beams **421**, **422**, **423**, **424**, **425**, and **426** can be configured with direction, beamwidth, amplification levels, and interference patterns to obtain quality coverage of participants, **411**, **412**, **413**, **414**, **415**, and **416**, respectively.

FIG. **5** illustrates a top view and a side view of a conference room including participants and a conferencing apparatus **100** disposed on a wall and illustrating beams that may be formed by the beamforming microphone array **135** disposed in the conferencing apparatus **100**. Beams **521**, **522**, **523**, **524**, **525**, and **526** can be configured with direction, beamwidth, amplification levels, and interference patterns to obtain quality coverage of participants, **511**, **512**, **513**, **514**, **515**, and **516**, respectively.

In FIGS. **3-5**, the azimuth angles and beamwidths may be fixed to cover desired regions. As a non-limiting example, the six beams illustrated in FIG. **3** and FIG. **4** can each be configured with beamwidths of 60 degrees with the beamforming microphone array **135**. The elevation angle of each beam is designed to cover most people sitting at a table. As a non-limiting example, an elevation angle of 30 degrees may cover most tabletop applications. On the other hand, for a ceiling application, the elevation angle is usually higher as shown in FIG. **4**. As a non-limiting example, an elevation angle closer to 60 degrees may be appropriate for a ceiling application. Finally, for a wall application, as shown in FIG. **5**, the elevation angle may be appropriate at or near zero degrees.

While these default elevation angles may be defined for each of the orientations, the user, installer, or both, have flexibility to change the elevation angle with software settings at the time of installation, before a conference, or during a conference.

A beamforming microphone array substantially improves audio quality in teleconferencing applications. Furthermore, some embodiments of the present disclosure use a teleconferencing solution with a beamforming microphone array that incorporates acoustic echo cancelation (AEC) to enhance full duplex audio quality.

For high quality in teleconferencing applications, audio of the far-end participant picked up by microphones of the beamforming microphone array **135** can be canceled before transmitting. This is achieved by an acoustic echo canceler (AEC) that uses the loudspeaker audio of the far-end participant as a reference. In the case of the beamforming microphone array **135**, there are multiple ways of doing acoustic echo cancelation in combination with beamforming.

Two strategies, "AEC first" and "beamformer first," have been proposed to combine an acoustic echo canceler with a beamforming microphone array. The "beamformer first" method performs beamforming on microphone signals and subsequently echo cancelation is applied on the beamformed signals. The "beamformer first" method is relatively computational friendly but requires continuous learning in the echo canceler due to changing characteristics of the beamformer. Often these changes renders the "beamformer first" method impractical for good conferencing systems.

On the other hand, an "echo canceler first" system applies echo cancelation on each microphone signal and subsequently beamforming is applied on the echo canceled signals. The "AEC first" system provides better echo cancelation performance but is computationally intensive as the echo cancelation is applied for every microphone in the microphone array. The computational complexity increases with an increase in the number of microphones in the microphone array. This computational complexity often limits the number of microphones used in a microphone array and therefore prevents achievement of the substantial benefit from the beamforming algorithm with more microphones.

Embodiments of the present disclosure implement a conferencing solution with beamformer and echo canceler in a hybrid configuration with a "beamformer first" configuration to generate a number of fixed beams followed by echo cancelers for each fixed beam. This hybrid configuration allows an increase in the number of microphones for better beamforming without the need for additional echo cancelers as the number of microphones is increased. Also, the echo cancelers do not need to continually adapt because as the number of fixed beams may be held constant. Therefore, embodiments of the present disclosure provide good echo cancelation performance and the increase in the computational complexity for large number microphones is smaller than the "AEC first" methods.

FIG. **6** illustrates elements involved in sensing acoustic waves with a plurality of microphones and signal processing that may be performed on the sensed acoustic waves. In an acoustic environment on the left of FIG. **6**, an acoustic source **610** (e.g., a participant) may generate acoustic waves **612**. In addition, speakers **620**A and **620**B may generate acoustic waves **622**A and **622**B, respectively. A beamforming microphone array **135** senses the acoustic waves (**612**, **622**A, and **622**B). Amplifiers **634** may filter and modify the analog signals to the speakers **620**A and **620**B and from the beamforming microphone array **135**. Converters **640** in the form of analog-to-digital converters and digital-to-analog converters convert signals between the analog domain and the digital domain. Various signal-processing algorithms may be performed on the digital signals, such as, for example, acoustic echo cancelation **650**, beamforming **660**, and noise suppression **670**. Resulting digital signals may be then transmitted, such as, for example through a voice over Internet Protocol application **680**.

Broadly, two configurations for the signal processing may be considered: "beamformer first" and "echo canceler first." FIG. **5** illustrates an echo canceler first configuration. The following discussion concentrates primarily on the signal processing operations and how beamforming and acoustic echo cancelation may be performed in various configurations. Generally, in FIGS. **7** through **9** thicker lines represent multichannel signals with the number of lines illustrated, whereas thinner lines represent a single channel signal.

FIG. **7** illustrates processing involved in sensing acoustic waves wherein signals from all of the microphones are combined, then acoustic echo cancelation is performed on the combined signal to create a combined echo canceled signal. The beamforming microphone array **135** generates a set of N microphone signals **138**. This "beamformer first" configuration uses the microphone signals **138** to define a beam in the direction indicated by a direction-of-arrival (DOA) determination process **750**. The DOA determination process **750** directs a beamforming process **730** to properly combine the microphone signals **138** into a combined signal **735**. An acoustic echo canceler **740** then performs acoustic echo cancelation on the combined signal **735** to create a combined echo-canceled signal **745**.

FIG. **8** illustrates processing involved in sensing acoustic waves wherein acoustic echo cancelation is performed on signals from each of the microphones, then the echo canceled signals are combined, to create a combined echo-canceled signal. The beamforming microphone array **135** generates a set of N microphone signals **138**. In this "AEC first" configuration, an acoustic echo cancel process **830** performs acoustic echo cancelation on each microphone signal **138** separately. Thus, a set of N echo-canceled signals **835** are presented to a beamforming process **840**. A DOA determination process **850** directs a beamforming process **840** to properly combine the echo-canceled signals **835** into a combined echo-canceled signal **845**. Since echo is canceled beforehand in the "AEC first" method, the echo canceler performance is not affected by beam switches. On the other hand, the "AEC first" configuration first cancels the echo from the audio of each microphone and the beam is created from N echo-canceled signals in the direction pointed to by the DOA determination process **850**. In terms of spatially filtering the audio, both configurations are substantially equivalent.

However, echo cancelation performance can be significantly different from one application to another. Specifically, as the beam is moving, the echo canceler needs to readjust. In a typical conferencing situation, talker directions keep switching and, therefore, the echo canceler needs to readjust, which may result into residual echo in the audio sent to the far end.

While the "AEC first" configuration provides acceptable performance for the beamformer/AEC implementation, the computational complexity of this configuration is significantly higher than the "beamformer first" configuration. Moreover, the computation complexity to implement the "AEC first" configuration increases significantly as the number of microphones used to create beam increases. Therefore, for given computational complexity, the maximum number of microphones that can be used for beamforming is lower for the "AEC first" configuration than the "beamformer first" configuration. Using comparatively more number of microphones can increase audio quality of the participants, especially when a participant moves farther away from the microphones.

FIG. **9** illustrates processing involved in sensing acoustic waves wherein a subset of signals from the microphones are combined, then acoustic echo cancelation is performed one or more of the combined signals. The beamforming microphone array **135** generates a set of N microphone signals **138**. In this hybrid configuration, a beamforming process **930** forms M fixed beams **935** from N microphone signals **138**. An acoustic echo cancel process **940** performs acoustic echo cancelation on each of the M fixed beams **935** separately. As a result M combined echo-canceled signals **945** are generated. A multiplexer **960** controlled by the DOA determination process **950** selects one or more of the M combined echo-canceled signals **945** as final output signals **965**.

In order to balance computation complexity of the complete system and number of microphones to do beamforming, the configuration of FIG. **9** creates M combined echo-canceled signals **945** to present as the final output signals **965**.

In teleconferencing application including beamforming, increasing the number of beams does not add as much benefit as increasing the number of microphones. Therefore, while a large number of microphones may be used to create good beam pattern in the hybrid configuration, the increase in computational complexity due to additional echo cancelers is significantly smaller than the "AEC first" configuration. Furthermore, since the beam is selected after the echo cancelation, echo cancelation performance is not affected due to change in the beam location. It should be noted that the number of echo cancelers does not need to change with a changing number of microphones. Furthermore, since the beamforming is done before the echo cancelation, the echo canceler also performs better than the "AEC first" setup.

FIG. **10** illustrates computational complexity of various embodiments relative to number of microphones in a beamforming microphone array. The computational complexity for various configurations and number of microphones was calculated in terms of required million-multiplications per second (MMPS) and is shown in FIG. **10**. It can be seen that the computational complexity for all methods increase as the number of microphones increase. However, the increase in the computational complexity for the "beamformer first" configuration and the hybrid configuration is much smaller than that of the "AEC first" configuration. With low computational complexity, and the fact that the implementation of the hybrid configuration has less chance of errors in the echo cancelation as a talker's direction switches, the hybrid configuration a good balance between quality and computational complexity for audio conferencing systems.

While the present disclosure has been described herein with respect to certain illustrated embodiments, those of ordinary skill in the art will recognize and appreciate that the present invention is not so limited. Rather, many additions, deletions, and modifications to the illustrated and described embodiments may be made without departing from the scope of the invention as hereinafter claimed along with their legal equivalents. In addition, features from one embodiment may be combined with features of another embodiment while still being encompassed within the scope of the invention as contemplated by the inventor.

What is claimed is:

1. A method of echo cancellation for a conferencing application, comprising:

sensing acoustic waves with a plurality of microphones to develop a corresponding plurality of microphone signals;

performing a beamforming operation to combine the plurality of microphone signals to a plurality of combined signals that is greater in number than one and less in number than the plurality of microphone signals, each of the plurality of combined signals corresponding to a different fixed beam;

performing an acoustic echo cancelation operation on the plurality of combined signals to generate a plurality of combined echo-canceled signals; and

selecting one or more of the plurality of combined echo-canceled signals for transmission.

2. The method of claim **1**, further comprising performing a direction-of-arrival determination on the plurality of microphone signals and wherein selecting one or more of the plurality of combined echo-canceled signals is performed responsive to the direction-of-arrival determination.

3. The method of claim **1**, wherein sensing the acoustic waves with the plurality of microphones comprises sensing the acoustic waves with a beamforming microphone array.

4. The method of claim **1**, further comprising noise filtering the plurality of combined signals prior to performing the acoustic echo cancelation operation.

5. The method of claim **1**, further comprising noise filtering the selected one or more of the plurality of combined echo-canceled signals.

6. The method of claim **1**, further comprising transmitting the selected one or more of the plurality of combined echo-canceled signals.

7. The method of claim **1**, further comprising:

sensing an orientation of a housing bearing the plurality of microphones; and

automatically adjusting a signal-processing characteristic of one or more of the microphones responsive to the sensed orientation.

8. A conferencing apparatus, comprising:

a plurality of microphones oriented to cover a plurality of direction vectors to develop a corresponding plurality of microphone signals; and

a processor operably coupled to the plurality of microphones and configured to:

perform a beamforming operation to combine the plurality of microphone signals to a plurality of combined signals that is greater in number than one and less in number than the plurality of microphone signals, each of the plurality of combined signals corresponding to a different fixed beam;

perform an acoustic echo cancelation operation on the plurality of combined signals to generate a plurality of combined echo-canceled signals; and

select one or more of the plurality of combined echo-canceled signals for transmission.

9. The conferencing apparatus of claim **8**, wherein the processor is further configured to perform a direction-of-arrival determination on the plurality of microphone signals and wherein selecting one or more of the plurality of combined echo-canceled signals is performed responsive to the direction-of-arrival determination.

10. The conferencing apparatus of claim **8**, wherein the plurality of microphones are configured as a beamforming microphone array.

11. The conferencing apparatus of claim **8**, wherein the processor is further configured to noise filter the selected one or more of the plurality of combined echo-canceled signals.

12. The conferencing apparatus of claim **8**, wherein the processor is further configured to noise filter the plurality of combined signals prior to performing the acoustic echo cancelation operation.

13. The conferencing apparatus of claim **8**, wherein the processor is further configured to transmit the selected one or more of the plurality of combined echo-canceled signals.

14. The conferencing apparatus of claim **8**, further comprising an orientation sensor configured to generate an orientation signal indicative of an orientation of a housing bearing the plurality of microphones and wherein the processor is further configured to execute the computing instructions to automatically adjust a signal-processing characteristic of one or more of the microphones responsive to the orientation signal.

15. A conferencing apparatus, comprising:

a beamforming microphone array for developing a plurality of microphone signals, each microphone of the beamforming microphone array is configured to sense acoustic waves from a direction vector substantially different from other microphones in the beamforming microphone array;

a memory configured for storing computing instructions; and

a processor operably coupled to the beamforming microphone array and the memory, the processor configured to execute the computing instructions to:

perform a beamforming operation to combine the plurality of microphone signals to a plurality of combined signals that includes a number of signals between one and a number of signals in the plurality of microphone signals, each of the plurality of combined signals corresponding to a different fixed beam; and

perform an acoustic echo cancelation operation on the plurality of combined signals to generate a plurality of combined echo-canceled signals.

16. The conferencing apparatus of claim **15**, wherein the processor is further configured to perform a direction-of-arrival determination on the plurality of microphone signals and select one or more of the plurality of combined echo-canceled signals responsive to the direction-of-arrival determination.

17. The method of claim **16**, further comprising transmitting the selected one or more of the plurality of combined echo-canceled signals.

18. The conferencing apparatus of claim **15**, further comprising an orientation sensor configured to generate an orientation signal indicative of an orientation of the beamforming microphone array and wherein the processor is further configured to execute the computing instructions to automatically adjust a signal-processing characteristic of one or more of the microphones responsive to the orientation signal.

19. The conferencing apparatus of claim **18**, wherein the processor is further configured to execute the computing instructions to automatically adjust a number of the microphones participating in the beamforming microphone array responsive to the orientation signal.

20. The conferencing apparatus of claim **18**, wherein the processor is further configured to execute the computing instructions to automatically adjust at least one microphone of the beamforming microphone array by adjusting a signal-processing characteristic selected from the group consisting of an amplification level, the direction vector, an interference pattern with another directional microphone of the beamforming microphone array, or a combination thereof.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 9,264,553 B2
APPLICATION NO. : 13/493921
DATED : February 16, 2016
INVENTOR(S) : Ashutosh Pandey et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the specification

In column 6, line 51, delete “that that” and insert -- that --, therefor.

In column 8, line 55, delete “622B,” and insert -- 622B --, therefor.

In the claims

In column 12, line 39, in claim 17, delete “method” and insert -- conferencing apparatus --, therefor.

Signed and Sealed this
Tenth Day of May, 2016

Michelle K. Lee

Michelle K. Lee
Director of the United States Patent and Trademark Office

EXHIBIT B

EXHIBIT C

EXHIBIT D

EXHIBIT E

EXHIBIT F

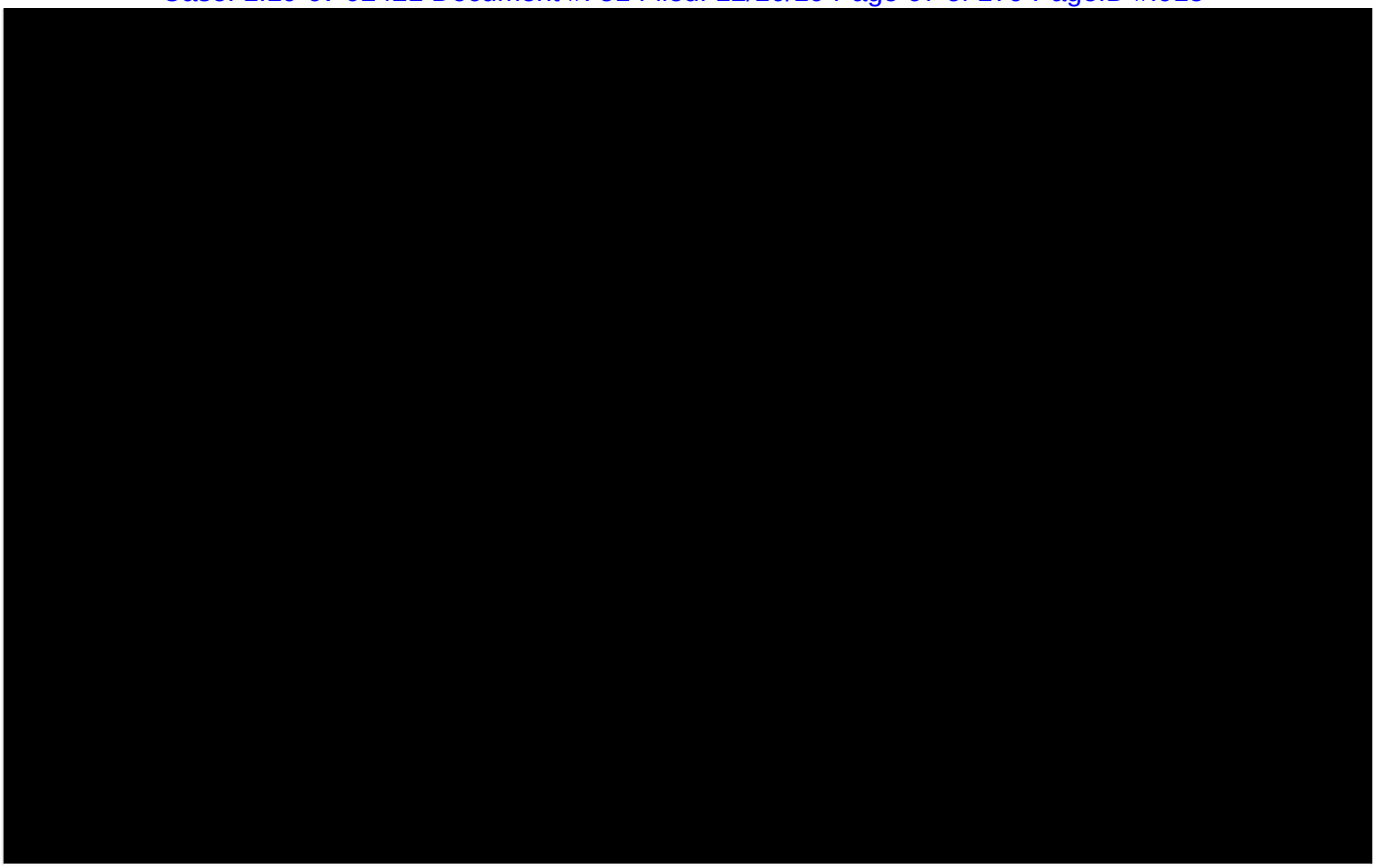


EXHIBIT G

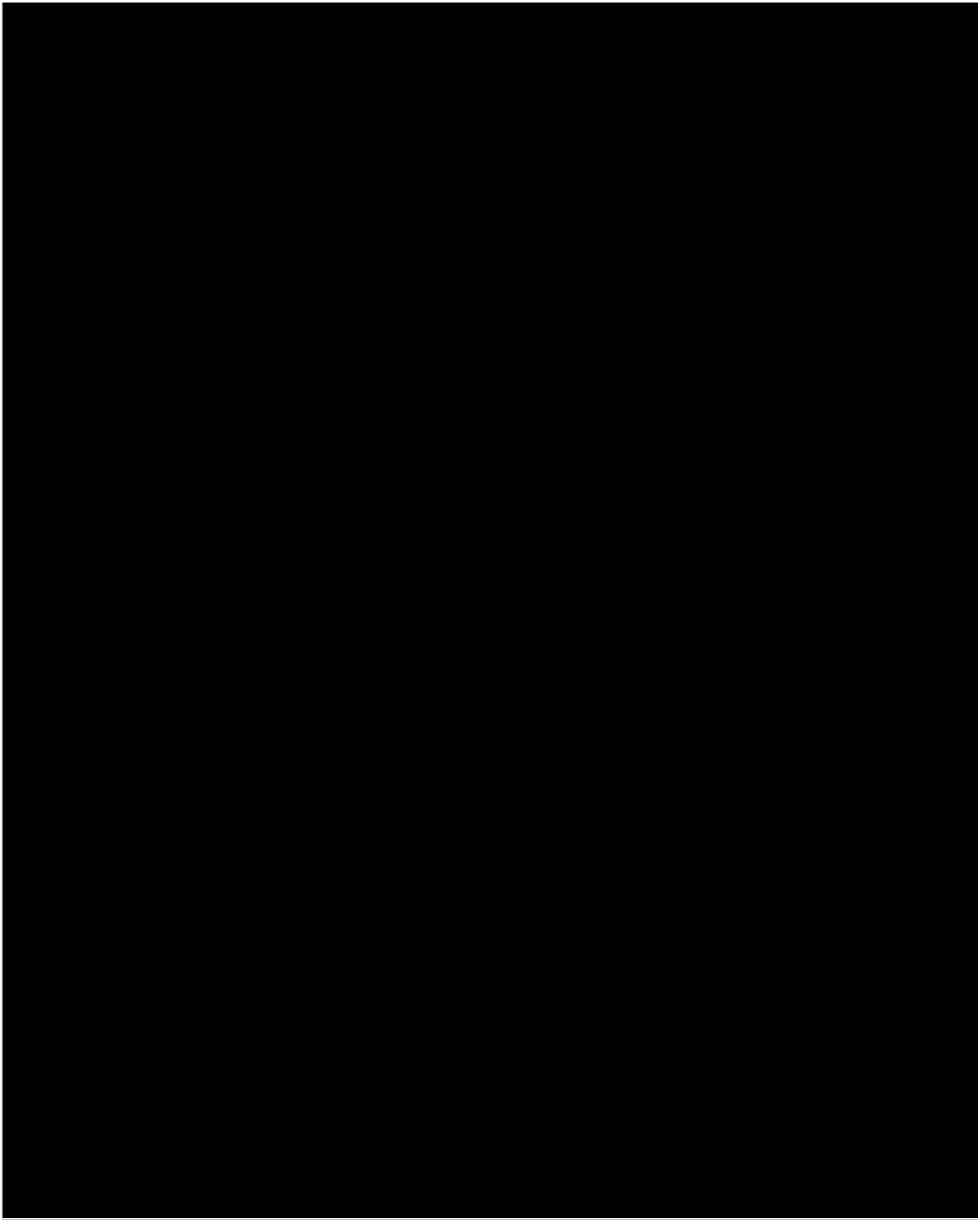


EXHIBIT H

Main Overview

General Description

The Microflex® Advance™ table array is a premium networked tabletop microphone for AV conferencing environments, including boardrooms, huddle rooms and multi-purpose spaces. Revolutionary technology from the IntelliMix® DSP suite includes Steerable Coverage™ , with selectable polar patterns on four independent channels to capture participant audio. The innovative new toroid polar pattern delivers 360° coverage, while rejecting sound from directly above the microphone. Browser-based control software provides an intuitive user interface for microphone attributes, including channel configuration, automatic mix settings, and preset templates. The microphone integrates seamlessly with Dante™ digital networked audio and third-party preset controllers, including Crestron and AMX, to deliver a high-quality AV Conferencing experience that appeals equally to integrators, consultants, and meeting participants.

Features

Configurable Coverage

- Steerable Coverage™ delivers precise pick-up for up to 4 independent lobes
- IntelliMix® DSP Suite provides fast-acting automatic mixing and channel equalization
- Innovative toroid polar pattern delivers 360° coverage, while rejecting sound from directly above the microphone to reduce noise caused by HVAC systems or video projectors.

Software Control

- Intuitive software interface provides comprehensive microphone and pattern control
- Includes templates to speed initial set-up and 10 customizable presets to import or export configurations between multiple microphones

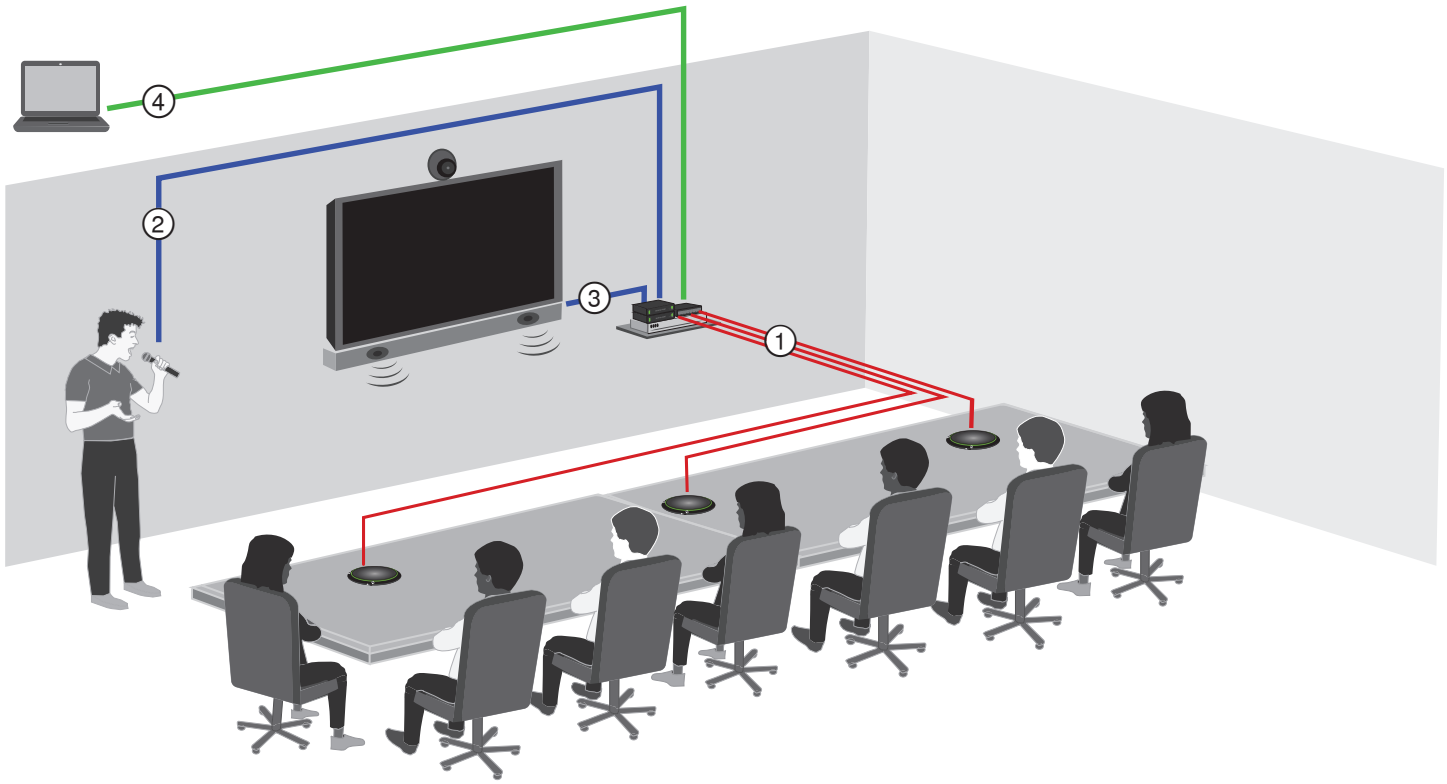
Network Connectivity

- Four discrete audio channels and an additional automix channel are delivered over a single network cable
- Dante™ digital audio coexists safely on the same network as IT and control data, or can be configured to use a dedicated network
- Control strings available for third-party preset controllers including Crestron and AMX

Professional Design

- Sleek, low-profile industrial design blends with contemporary board rooms and meeting spaces
- Configurable multi-colored LED light ring matches the environment, displays mute settings, and confirms coverage settings
- Available in white, black, and aluminum finishes

System Overview



① Dante™ audio, power, and control
A single network cable delivers 4 discrete audio channels from each microphone onto the Dante network, where they can be routed to any Dante™ -compatible devices.

② Analog audio (microphone to network)
Analog equipment, such as a wireless microphone system or a gooseneck microphone on a podium, connects to the Dante™ audio network through a Shure Network Interface (model ANI4IN) for a completely networked conferencing system.

③ Far-end audio (network to loudspeakers)
Dante™-enabled loudspeakers and amplifiers connect directly to a network switch. Analog loudspeakers and amplifiers connect through a Shure Network Interface (model ANI4OUT), which converts Dante™ audio channels into analog signals, delivered through 4 discrete XLR or block connector outputs.

④ Device control and Dante™ audio
A computer running Dante™ Controller and the Shure browser-based interface provides control over the following:

System Planning and Gear Requirements

Setting up the Audio Network

Shure networked conferencing systems are comprised of Microflex Advance microphones and network interfaces, which operate entirely on a Dante™ network. Additional hardware, including network switches, computers, loudspeakers, and audio processors are described in the hardware component index.

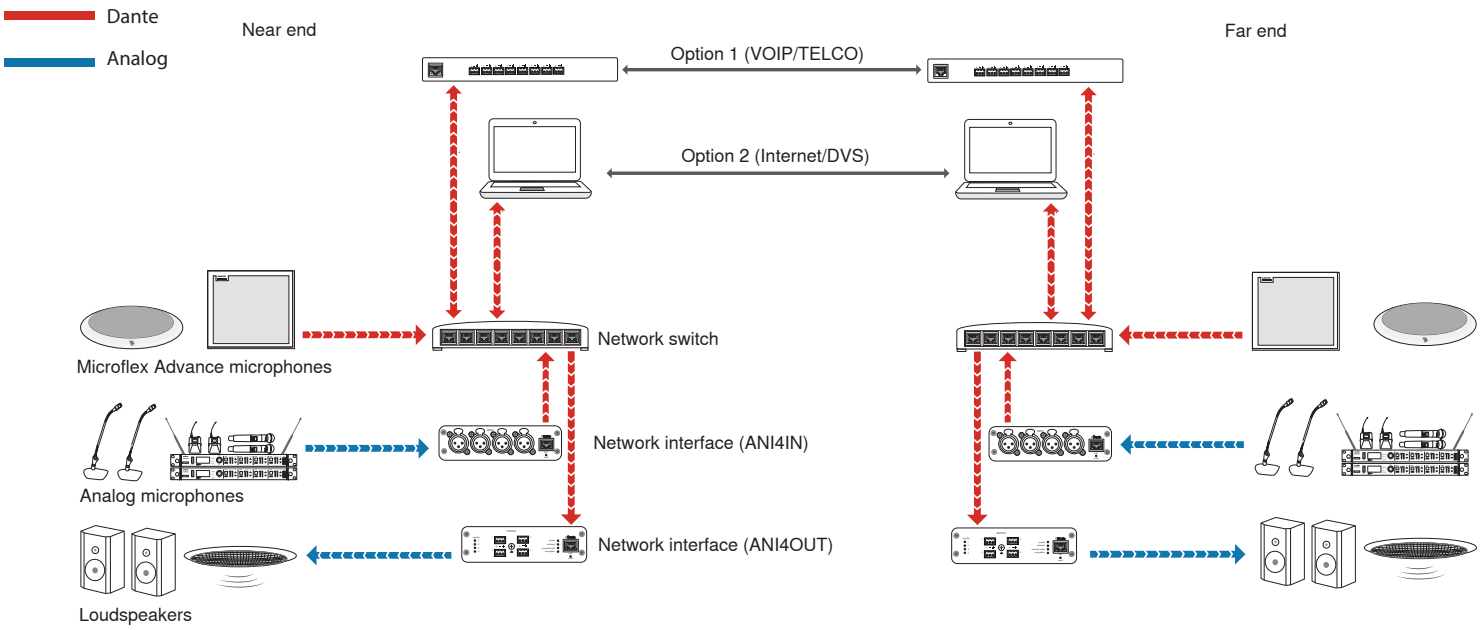
Shure components shown in this diagram:

Microflex Advance Microphones
The MXA910 and MXA310 are equipped with Dante outputs, and connect directly to a network switch.

Audio Network Interfaces
The interfaces are used to connect analog devices such as loudspeakers and analog microphones to the network.

ANI4IN: Converts 4 analog signals (separate XLR and block connector models available) into Dante™ digital audio signals.

ANI4OUT: Converts 4 channels of Dante™ audio from the network into analog signals.



This diagram shows the entire signal path through a networked conference system. Signals from the near end and far end are exchanged through an audio processor connected to a phone system, or through a computer connected to the internet. Analog microphones connect to the network through the Shure ANI4IN, while loudspeakers connect through the Shure ANI4OUT.

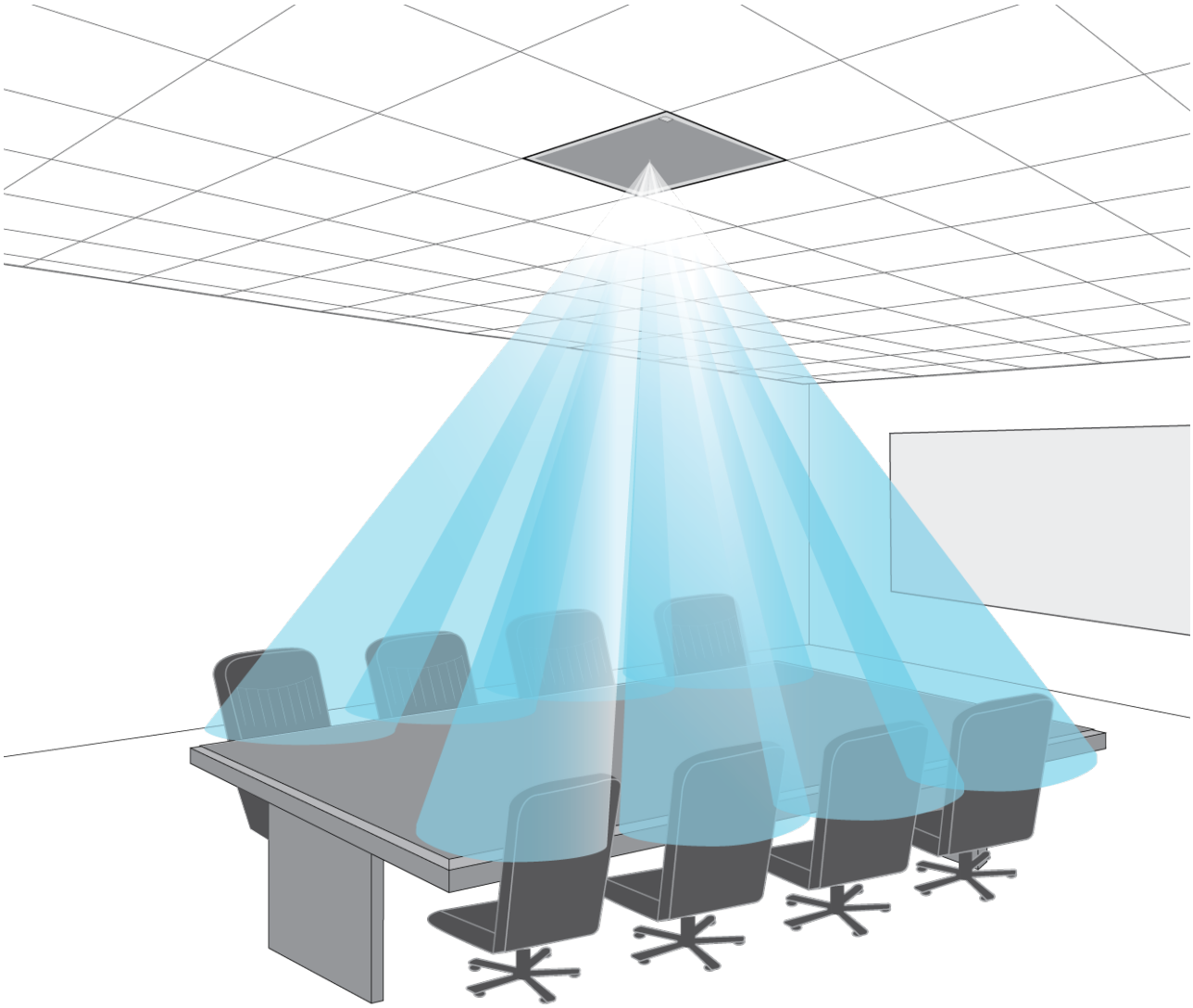
EXHIBIT I

MXA910 -- Ceiling Array Microphone

Overview

General Description

The Microflex®Advance™ Ceiling Array is a premium networked array microphone for AV conferencing environments, including boardrooms, huddle rooms, and multi-purpose spaces. Revolutionary technology from the Shure DSP suite includes Steerable Coverage™, with 8 highly directional pickup lobes that capture participant audio from overhead. Control the microphone with Shure Designer software, or a browser-based web application. The microphone integrates seamlessly with Dante™ digital networked audio and third-party preset controllers, including Crestron and AMX, to deliver a high-quality AV conferencing experience that appeals equally to integrators, consultants, and meeting participants.



Features

Configurable Coverage

- Steerable Coverage delivers precise pickup for up to 8 independent lobes
- Shure DSP Suite provides fast-acting automatic mixing, echo reduction, and channel equalization

Software Control

- Shure Designer software provides comprehensive microphone and pattern control
- With Designer, you can also design coverage with online and offline devices, and route audio between Shure devices
- If Designer isn't available, use the browser-based web application to control the microphone

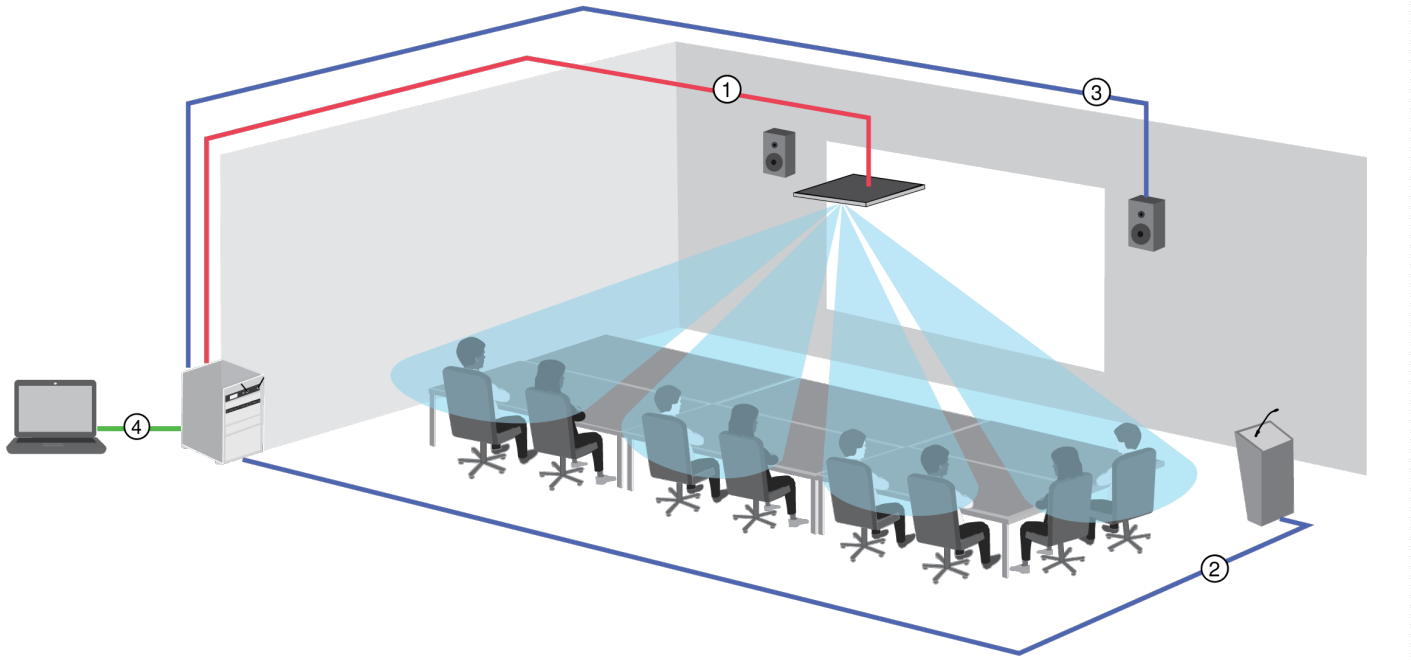
Network Connectivity

- Discrete audio channels for each lobe and an automix channel are delivered over a single network cable
- Dante digital audio coexists safely on the same network as IT and control data, or can be configured to use a dedicated network
- Control strings available for third-party preset controllers including Crestron and AMX

Professional Design

- Sleek industrial design blends with contemporary board rooms and meeting spaces
- Seamless flush-mount with standard ceiling tiles
- Available in white, black, and aluminum finishes (detachable grille can be custom painted)

System Overview



① Dante audio, power, and control

Each array microphone connects to the network over a single network cable, which carries Dante audio, Power over Ethernet (PoE), and control information to adjust coverage, audio levels, and processing.

② Analog audio (microphone to network)

Analog equipment, such as a wireless microphone system or a gooseneck microphone on a podium, connects to the Dante audio network through a Shure Network Interface (model ANI4IN) for a completely networked conferencing system.

③ Far-end audio (network to loudspeakers)

Dante-enabled loudspeakers and amplifiers connect directly to a network switch. Analog loudspeakers and amplifiers connect through a Shure Network Interface (model ANI4OUT), which converts Dante audio channels into analog signals, delivered through 4 discrete XLR or block connector outputs.

④ Device control and Dante audio

Control: A computer connected to the network controls the microphone with Shure Designer software. You can remotely adjust coverage, muting, LED behavior, lobe settings, gain, and network settings.

Audio: Route audio with Dante™ Controller or Shure Designer software. Dante Virtual Soundcard enables audio monitoring and recording directly on the computer.

EXHIBIT J

SHURE
SOUND EXTRAORDINARY

MENU

Shure Expands Partnership Program With Leading AV Hardware and Software Providers

FEBRUARY 7, 2017

EPPINGEN, GERMANY, February 7, 2017—Shure Incorporated has announced a number of additions to its partnership program, which provide an expanded level of integration between Shure wired and wireless audio systems and other leading AV hardware and software. Shure now has formed partnerships with Cisco, Crestron, Polycom, Biamp, QSC, Symetrix, Yamaha, Audinate, Chief and others.

The partnership program ranges from information for system integrators, such as configuration and setup guides that ensure optimum performance, to embedded plug-ins that provide native control and audio integration. The goal is to communicate that Shure audio products like Microflex® Advance™ and Microflex Wireless have been tested and are compatible with popular downstream equipment. This reduces setup and configuration time for system integrators and administrators and streamlines the workflow involved in using the completed system.

“It’s not just about how well products work; it’s about how well products work together,” said Chad Wiggins, Senior Category Director for Networked Systems at Shure. “The goal of our partnership program is to enhance the ‘Five Cs’ -- connectivity, control, customization, confidence, and convenience – for our customers. Our success in the marketplace depends more than ever on how easy it is to use Shure products with other brands and other types of products. That’s why it’s critical that we continue to form partnerships with other significant companies in the AV industry.”

Contact Public Relations:

Shure Incorporated
Attn: Allison Dolegowski

Telephone: (312) 736 6000
publicrelations@shure.com

Shure Blog

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Mixers & DSP

Software

Discussion Systems

Headphones

RESOURCES

Service & Repair

Find An Answer

Tools

Sweepstakes Rules

POPULAR LINKS

SM58 Vocal Microphone

BLX Wireless Systems

SE215 Sound Isolating™ Earphones

ULX-D Digital Wireless Systems

SM57 Instrument Microphone

QLX-D Digital Wireless Systems

EXHIBIT K

Shure

Shure

Software Integration Alliance

Shure Global Website
Shure Support

Shure and QSC have co-developed a control plugin for their Microflex Wireless microphone series. In addition, specific microphones in the Shure catalog, including the Microflex Wireless series, can pass audio to the Q-SYS Platform via AES67, all without additional Dante I/O card hardware.

Microflex Wireless

Microphone Solutions for

Description: Microflex® Wireless provides elegant solutions for managing vivid, lifelike sound in AV conferencing environments. Its audio integrates with Q-SYS either through AES67 (without additional hardware) or through Q-SYS Dante I/O card. Q-SYS Designer software also has a built-in control and monitoring plugin available for the Shure Microflex Wireless System. Includes RF Signal status, Level status, Mute and Identify functionality for each microphone.

EXHIBIT L

audiobiz

QSC and Shure to offer integration between Shure Microflex networked microphones and entire Q-SYS Platform (/latest-news/2017/1/11/qsc-and-shure-to-offer-integration-between-shure-microflex-networked-microphones-and-entire-q-sys-platform)

Travis Brown (/latest-news?author=586ff2d13e00be70aef97e2e) · January 11, 2017 (/latest-news/2017/1/11/qsc-and-shure-to-offer-integration-between-shure-microflex-networked-microphones-and-entire-q-sys-platform)

Partnership provides native control and audio integration for best-in-class conference room microphones and AV solutions

Costa Mesa, Calif. (January 9, 2017) QSC, LLC and Shure Incorporated are proud to announce an expanded level of integration between Shure Microflex® Advance™ and Microflex® Wireless microphones with the entire Q-SYS™ Platform. The partnership includes the release of new control plug-ins for the Shure MXA910 Ceiling Array Microphone and Microflex Wireless microphone systems. The latest Q-SYS Designer Software v5.3 update enables a multitude of audio connectivity options including audio integration via Dante, analog audio as well as AES67. Simple setup and configuration is assured with the addition of a detailed quick start guide to integrate audio and control between the Shure and QSC systems.

The Shure MXA910 Control plug-in, co-developed by QSC and Shure, allows a myriad of different audio control, preset recall, and monitoring functions on the MXA910 from the Q-SYS platform using Q-SYS peripherals and touch screen controllers. Because the MXA910 control plug-in is decoupled from the audio integration method in Q-SYS, it lets the integrator use the plug-in for *control* while being able to choose between different *audio* transport methods, whether that be via analog audio using the Shure ANI series, the Q-SYS Dante Bridging card, or the newly-introduced AES67 software support on the Q-SYS Core processor series. By using AES67 as the audio integration method, every Q-SYS Core processor in the platform can be easily integrated with the MXA910 without any additional hardware bridging devices or software licenses. This includes the class-leading Q-SYS Core 110f, offering the industry's most cost effective pairing of DSP, AV Bridging, and Control with its 16 channels of AEC, which can accommodate up to two MXA910s in a single rack space over a single network connection.

The setup guide, also co-developed by QSC and Shure, provides step-by-step instructions on how to integrate the MXA910 with Q-SYS using AES67 for networked audio streaming and the built-in plug-in for control and monitoring of the MXA910 from Q-SYS.

"Integration at the software layer between Q-SYS and the Shure Microflex networked microphones provides integrators with the ability to offer truly unified, AV solutions to their end users for projects of any scale, including those leveraging the new Q-SYS AV-to-USB Bridging solution for conference room camera connectivity to soft-codec applications," explained Martin Barbour, Product Manager for Installed Systems at QSC. "By decoupling control integration from the audio transport mechanism, we offer the integrator the ability to choose the most appropriate audio transport method for their application while ensuring best-in-class performance from microphone through to loudspeaker, including all processing and amplification in between."

"We are tremendously excited to expand our partnership with QSC and to continue improving the overall experience for our shared customers," proclaimed Chad Wiggins, Senior Category Director of Networked Systems Products at Shure. "Offering control plug-ins in Q-SYS Designer Software for the Shure MXA910 Ceiling Array Microphone is a natural extension to the tools already available for Microflex Wireless Microphone Systems. In addition, the setup guide we co-developed provides a valuable resource for system designers considering the technical details of integrating the MXA910 with the Q-SYS platform using AES67. These are great examples of the commitment to improving user workflow and interoperability our two companies share."

Furthermore, because Q-SYS is the only software-based audio, video, and control Linux realtime operating system (RTOS) platform, it will enable QSC and Shure developers to expand the library of control plug-ins to other Shure products and allow integrators to incorporate them into future designs with a simple software update.

The Shure MXA Control Plug-in and setup guide will be available with the release of Q-SYS Designer Software v5.3 in early January 2017.

Newer Post
QSC Provides Glimpse into the Future of Audio, Video and Control Processing (/latest-news/2017/1/24/qsc-provides-glimpse-into-the-future-of-audio-video-and-control-processing)

Older Post
FAQ QLX-D Firmware Update Version 2.0.16 (/latest-news/2017/1/11/ljsf0c7k4g7dpb8gfuohfxqe0d03ex)

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EXHIBIT M

Press Releases

< Back

Dec 12, 2016

Biamp Systems and Shure Announce Tesira®-Microflex® Compatibility

BEAVERTON, Oregon and NILES, Illinois — Biamp Systems, a leading provider of innovative, networked media systems and Shure Incorporated, a leading manufacturer of networked microphones, today announced integrated compatibility between Biamp Tesira® audio processors and software and Shure Microflex® Advance™ array microphones with Steerable Coverage™. With the release of Biamp's new Tesira software and hardware at ISE in February 2017, it will be possible to interact with the Dante-enabled Shure MXA910 ceiling array microphone and control signal levels within the Tesira software. This will enable system integrators to deliver flexible, fully-digital audio solutions that meet the complex needs of their clients while reducing installation and setup time.

"We're excited to come together with an industry leader like Shure in an effort to streamline the integration of our products," shared Graeme Harrison, executive vice president of marketing for Biamp Systems. "Both companies value customer feedback and leverage it in future product development. Adding Shure microphone-specific software blocks to Tesira's cutting-edge software made sense; it allows system designers to easily incorporate the power of Shure mics with the power of Tesira. Other developments in this launch will bring this capability to the whole range of Tesira processors, and we will add additional functionality in future releases."

"Interoperability between the MXA910 ceiling array microphone and Tesira processors will make it easier for system integrators to take advantage of its class-leading voice pickup and steerable coverage in a wide assortment of meeting room applications," said Chad Wiggins, senior director for networked systems at Shure. "Together, they deliver a more powerful yet more streamlined solution, with centralized control, simpler installation, and fewer components."

Tesira's software is unique in that it enables system designers to build complete AV solutions using features like its intuitive drag-and-drop interface for a variety of software blocks. The Tesira software enables designers to plan a completely integrated AV solution, including yet-to-be-built future phases.

More information about Biamp and Shure is available at www.biamp.com and www.shure.com.

EXHIBIT N

Using TesiraFORTÉ DAN with Shure MXA310 and MXA910

The purpose of this article is to provide a starting point to aid in the successful deployment of the TesiraFORTÉ DAN with Shure MXA310 and/or MXA910 microphone arrays. Specific understanding of the Shure MXA products is best gleaned from documentation and training provided by Shure. Links to these resources can be found later in this article.

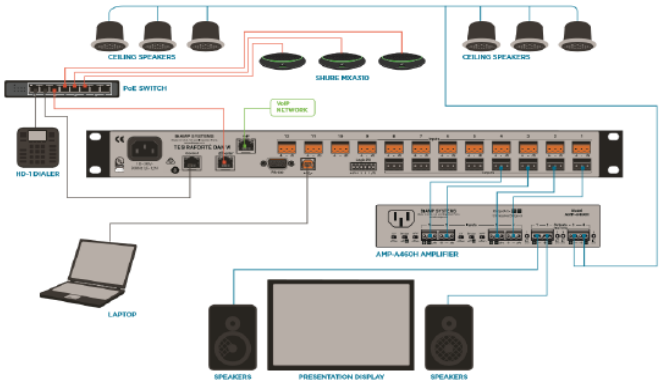
TesiraFORTÉ DAN

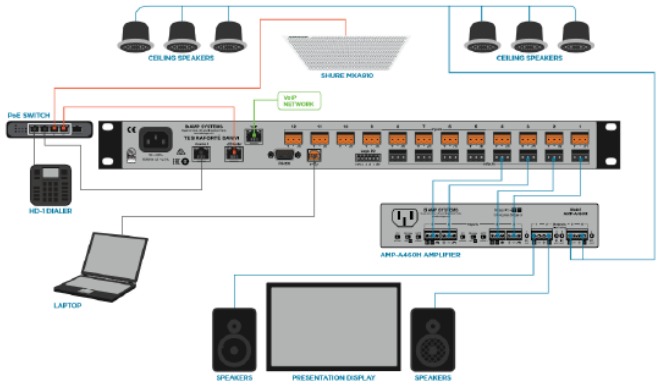
Interoperability

The TesiraFORTÉ DAN product family uses the same TesiraFORTÉ base platform we know and love and adds Dante audio networking. This offers streamlined interoperability with Shure MXA and MXW products as well as Dante products from other manufacturers. Each TesiraFORTÉ DAN is capable of 32 channels in and 32 channels out via the Dante network port. If you are working with an AEC capable TesiraFORTÉ DAN, then you now have up to 12 channels of AEC processing available for Dante microphone sources. This means that a single TesiraFORTÉ DAN can provide AEC processing for up to (3) MXA310 (4 channels each) or a single MXA910 (8 channels each).

Please note that the TesiraFORTÉ DAN VT4 only has 4 channels of AEC processing available and scale your system design accordingly.

Now, we'll borrow some imagery from our System Design Guides to help illustrate these examples:





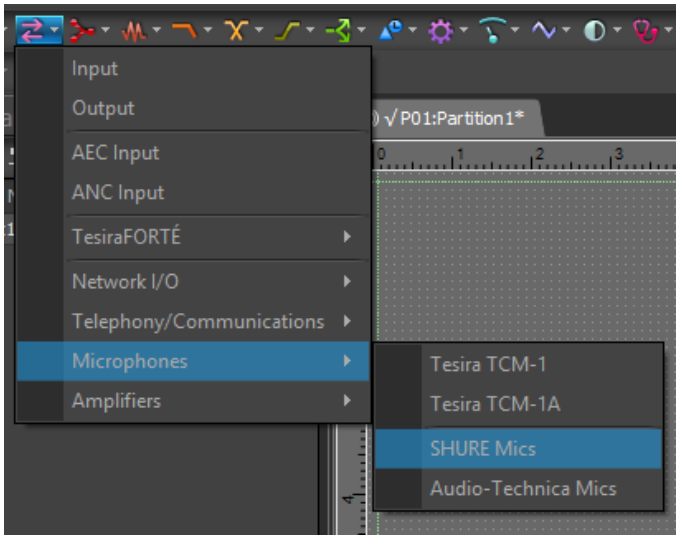
Biamp_System_Design_Guide_Boardroom_TesiraFORTE_DAN_MXA310_EN-US.pdf

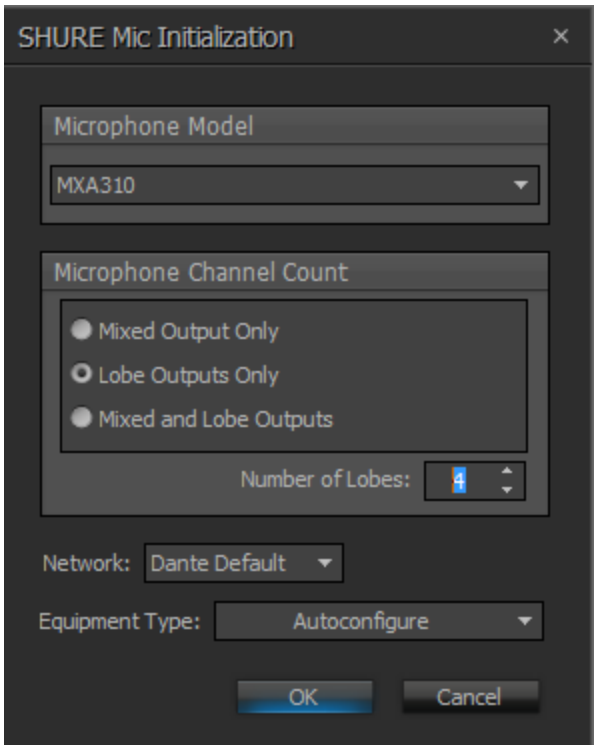
Biamp_System_Design_Guide_Boardroom_TesiraFORTE_DANMXA910_EN-US.pdf

Entire System Design Guide suite.

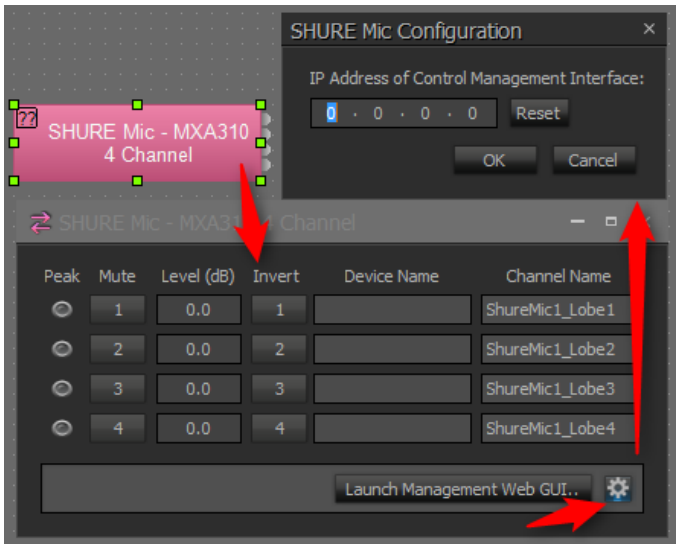
Tesira Software

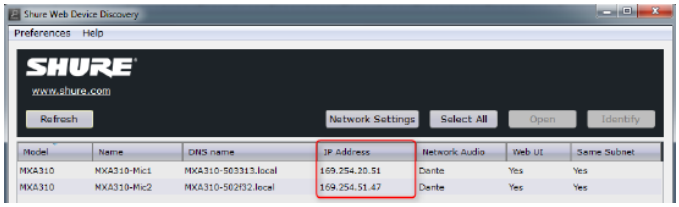
When designing a system file in Tesira software, there are now custom MXA310 and MXA910 blocks located under the "SHURE Mic" option. This can be found in the "Microphones" segment under I/O Blocks within the Object Bar. Once selected, you'll be prompted to choose the desired Microphone Model and Channel Count. The channel or lobe count will need to match the number of lobes expected from the source microphone array. It has been observed that using four individual lobe outputs with Biamp per channel AEC processing performs better than the mixed output option. However, each room and system is unique, so please select the appropriate initialization state.



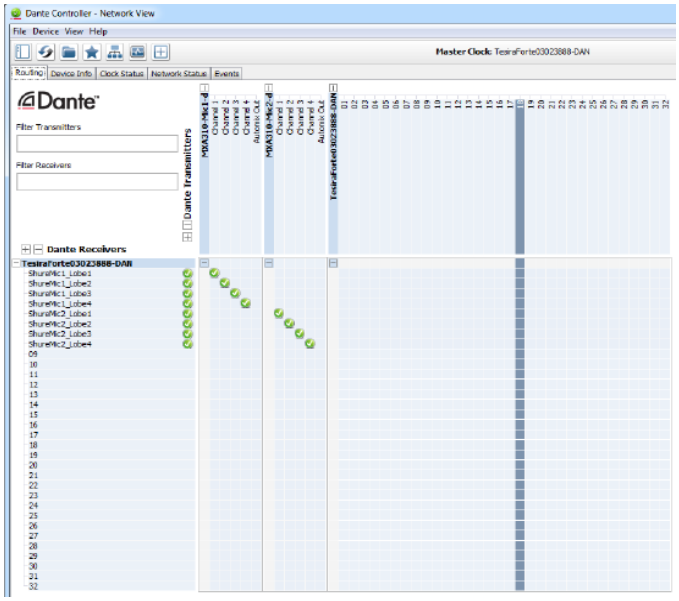


Now that the appropriate input block is created, add the corresponding Control IP Address of the respective MXA mic array in the SHURE Mic Configuration menu. Though not required, this will allow quick access to the Management Web GUI for this specific set of inputs. If the MXA mic array IP address has not already been documented, the Shure Web Device Discovery tool can be used to discover and adjust this information and as needed.





Once the Biamp configuration is sent to the Tesira, available Dante channels will populate within Dante Controller for proper routing.



Dante Hostname & IP Configuration

Dante devices obtain IP addresses automatically by default - so there should be no need to specify static IP addresses unless it is a specific requirement for your network.

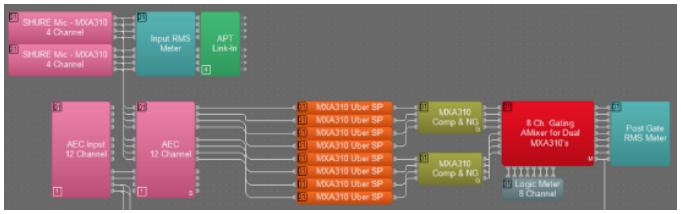
- You can configure static IP addresses and hostnames for the FORTE DAN Ethernet port using Tesira software. Note that these edits must be done with the Tesira in an unconfigured state (no system file loaded; Device ID = 0). In **Device Maintenance > Network Settings** choose the **DAN-1 (Slot x)** tab.
- If your network has a DHCP server, Dante devices will receive their IP configuration using the standard DHCP protocol.
- On a network without DHCP, a Dante-enabled device will automatically assign itself an address using ‘Bonjour’ Zero Config auto addressing protocol by Apple. Devices will automatically assign themselves an address in the range 169.254.*.* (172.31.*.* for the secondary / redundant network, if present).

DAN-1 MAC addresses are visible within **Device Maintenance > Network Settings** under the **DAN-1 (Slot x)** tab, choose the **Interface Status...** button.

MXA LED Control & Example Files

Below are some example files, images and downloadable resources. ***These example files include examples of how to control Mute state and LED's of the MXA310 & MXA910 from Tesira.***

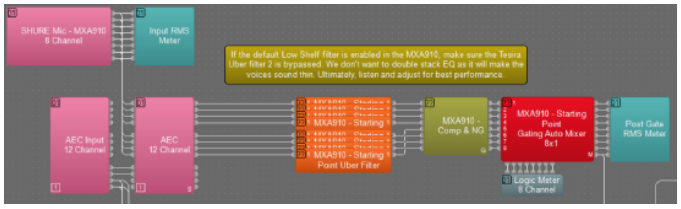
Dual MXA310 System:



File download: Dual_MXA310_Example_file_2017-2-3.tmf

File download: Dual_MXA310_Example_file_2017-2-3_Alt_Mute_Logic.tmf

Single MXA910 System:

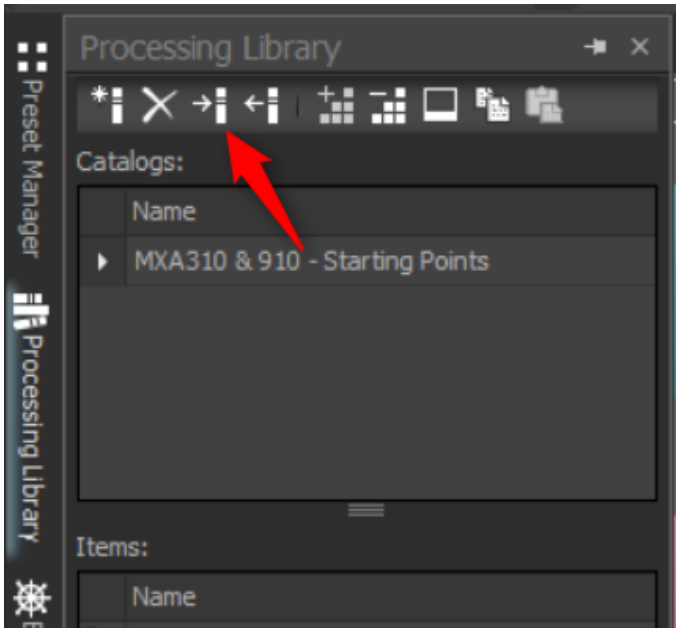


File download: Single_MXA910_Example_file_2017-8-4.tmf

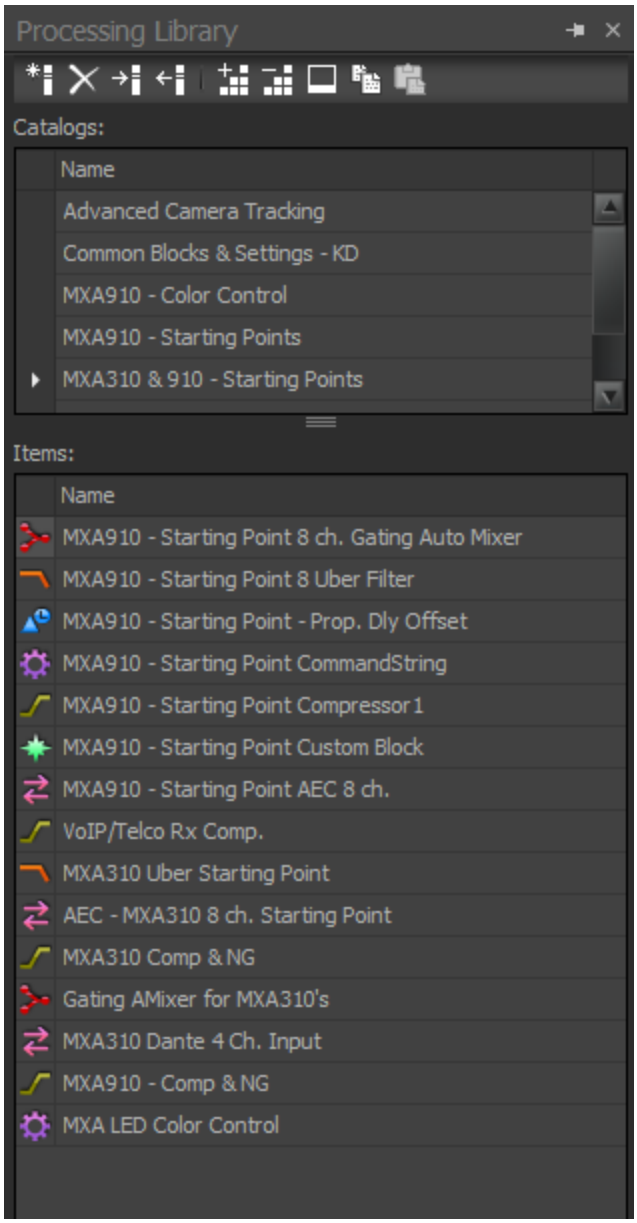
Processing Library:

File download: MXA910_-_Starting_Points_Catalog_v03.tlf

The Processing Library is a little known tool within Tesira software that allows users to create catalogs of their favorite blocks. These catalogs can be exported and shared with other Tesira users. The following image shows the icon used to import the library that was just downloaded.

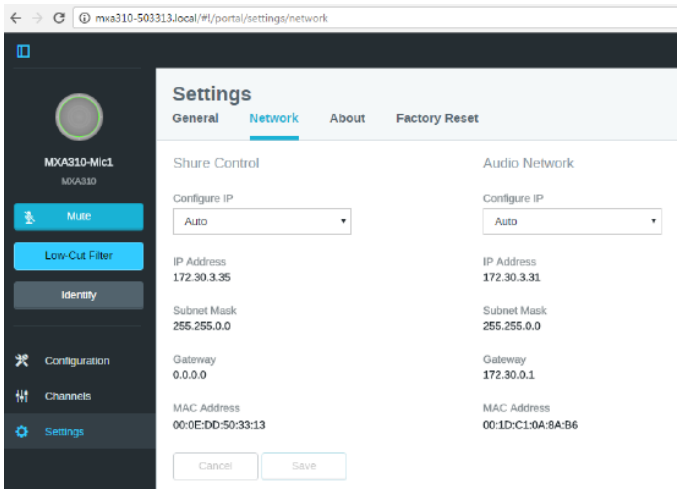


Now, when the Processing Library is opened you will see all of the items that comprise the selected catalog.
This catalog contains all the blocks that were used to build the example files above. These items can be added to the current system file simply by dragging and dropping them into the file.



Tips & Tricks:

- It is a good idea to plan out the IP scheme for each system ahead of time.
  - Each Shure MXA device requires two IP addresses, one for control and one for Dante.



  - The TesiraFORTÉ DAN will also require two IP addresses, one for control and one for Dante.
  - If these addresses are statically set, they will remain the same.
  - If these addresses are set to DHCP and drop to link-local (169.254.x.x), the microphones may hop to different IP addresses with each reboot. This would break control and auto-launch functions that were configured in Tesira.
  - If there is a DHCP server, it may be best to reserve the necessary IP addresses for the respective devices.
- It is also helpful to strategically name and document each Dante endpoint as this will make routing flows in Dante Controller much more intuitive.

Additional resources

Shure has provided the following documentation and resources for the MXA310:

- Shure MXA310 User Guide
- Shure article on Dante Networks & IGMP Snooping
- Shure Configuration Video
- Shure MXA310 Mounting Hole
- Shure Routing Dante Audio
- Shure MXA310 Interactive Software Demo
- Shure Microflex Advance Training - Video Suite

Further reading

- Using the Shure MXA910 microphone array with Tesira
- Configuring Audio-Technica Dante microphones
- Dante
- Gain Structure
- Microphone Placement

- Gain Sharing vs. Gating Automixers

EXHIBIT O

SHURE
SOUND EXTRAORDINARY

MENU

Using multiple MXA910 or MXA310 microphone arrays in a single room.

FAQ #4982 Updated September 07, 2017

Question:

Can I use more than one MXA910 ceiling array or MXA310 table arrays in a room? How do they connect together?

Answer:

Yes. Just like any other microphone, you may install multiples to cover a room.

The audio output from multiple ceiling arrays (or table arrays) can be combined with a mixer or external DSP (i.e. SCM820, or QSC Qsys, or Biamp). Multiple arrays cannot directly share DSP resources with each other.

The microphones cannot be daisy-chained together, but by installing a small network switch with PoE under the table or in a ceiling, multiple array microphones can be locally connected and then a single cable run from the switch back to a central location.

Note that each microphone must be configured independently. At this time, the embedded software in the device does not allow for multiple devices to be configured from a single interface.

Shure Designer software can be used allows multiple "virtual" MXA910 Ceiling Array Microphones to be configured in one tool. Arrange pickup lobes over a room diagram for precise coverage; import saved settings to each MXA910 on site.

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EXHIBIT P

UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF ILLINOIS
EASTERN DIVISION

SHURE, INC.,	)	
	)	
Plaintiff, Counter-Defendant,	)	No. 17 C 3078
	)	
v.	)	
	)	Judge Edmond E. Chang
CLEARONE, INC.,	)	
	)	
Defendant / Counter-Plaintiff.	)	

MEMORANDUM OPINION AND ORDER
(UNDER SEAL)

This litigation concerns two patents on audio conferencing technology. Shure, Inc. sued its competitor ClearOne (the owner of the patents), seeking a declaration of invalidity and non-infringement at first on U.S. Patent No. 9,635,186.[1] R. 1, Compl. ¶ 1.[2] In response, ClearOne filed a counterclaim for infringement against Shure.[3] R. 28, Counterclaim. After expedited discovery, ClearOne moved for a preliminary injunction to halt Shure's alleged infringement of the '186 Patent. R. 81, Mot. Prelim. Inj. '186 Patent (redacted). The Court denied ClearOne's motion. R. 279, Mem. Op. and Order (redacted). During the pendency of the first preliminary-injunction motion,

[1]The initial complaint also included claims about U.S. Patent No. 9,264,553, which also involved audio conferencing, but the inter partes review (IPR) on that patent prompted a dismissal of those claims, R. 280, though after the IPR finished, ClearOne filed a new case on it, R. 541. The Court has subject matter jurisdiction over this case under 28 U.S.C. § 1338(a).

[2]Citations to the record filings are "R." followed by the docket number and, when necessary, a page or paragraph number. Many exhibits have overlapping names or numbering, so exhibits will be identified by docket number throughout to avoid confusion.

[3]ClearOne's counterclaim also named Biamp Systems Corporation and QSC Audio Products, LLC, as counter-defendants. R. 28, Counterclaim. Biamp and QSC are not involved in the preliminary injunction litigation and were later dismissed from the case. R. 141.

ClearOne was granted another audio conferencing patent, U.S. Patent No. 9,813,806, and asserted infringement on that patent too. R. 260, Second Am. Compl. ClearOne later also moved for a preliminary injunction to halt Shure's alleged infringement of the '806 Patent, also based on Shure's MXA910. R. 369, Mot. Prelim. Inj. '806 Patent (redacted). In November 2018, the Court held a hearing on that motion and took it under advisement.

Meanwhile, the parties finished fact discovery and briefed their claim construction arguments on both the '186 and '806 Patents. *See* R. 508, Shure Claim Const. Br.; R. 520 ClearOne Claim Const. Resp. (redacted); R. 522, ClearOne Claim Const. Resp. (sealed); R. 535, Shure Claim Const. Reply. The Court heard oral argument on claim construction on July 12, 2019. *See* R. 520, Minute Entry. Arguments and evidence presented for the first time at the claim construction stage are discussed below where they are relevant to issues that had already been raised in the preliminary injunction context.[4]

After hearing arguments and reviewing the parties' evidence, the Court finds that ClearOne has met its burden of demonstrating entitlement to the extraordinary

[4]This Opinion includes claim construction decisions on the following construction issues and terms, which overlap with issues raised at the preliminary injunction stage: the person of ordinary skill in the art for the '806 Patent; "beamforming microphone array'"; "said beamforming microphone array integrated into said ceiling tile as a single unit"; "the drop space of the drop ceiling"; and "wherein said outer surface is coplanar with said ceiling tile."

The Court reserves its claim construction decisions on the '186 Patent terms, as well as the following terms from the '806 Patent, which do not overlap directly with issues raised at the preliminary injunction stage: "is acoustically transparent," and "used in a drop ceiling mounting configuration." The Court will issue a separate claim construction opinion on those terms.

relief of a preliminary injunction on the '806 Patent. ClearOne has shown a reasonable likelihood of success on the merits: Shure is likely infringing the '806 Patent and has not raised a substantial question of the patent's validity. ClearOne has established that it will suffer irreparable harm without a preliminary injunction, and the balance of harms and public interest tip in its favor. As discussed in the Opinion's end, the Court sets a prompt litigation schedule on the appropriate bond amount so that it may be decided and posted in order to make the preliminary injunction operative.

I. Background

A. The '806 Patent

The only patent at issue in this preliminary injunction motion is the '806 Patent (referred to by ClearOne as the "Graham Patent"). The '806 Patent claims an invention that combines a beamforming microphone array (commonly abbreviated in the industry as "BFMA") with a ceiling tile so that the BFMA can pick up sound throughout a conference room while remaining somewhat hidden from view. As ClearOne's expert, Dan Schonfeld, has explained it, "The Graham Patent covers the integration of beamforming microphones into a ceiling tile, which delivers audio through an acoustically-transparent outer surface, but conceals the microphone array on its backside, so that it can be seamlessly integrated into the drop ceiling of a room." R. 372, Schonfeld Decl. ¶ 25 (redacted).

The benefit of integrating a beamforming microphone array with a ceiling tile is that it allows the technology to be out-of-sight. In the context of audio conferencing,

the typical conference setup involves multiple attendees in one room, all communicating with attendees in another location. R. 372, Schonfeld Dec. ¶ 26 (redacted). The "conventional wisdom" has traditionally been that in such scenarios, microphones should be as close to the attendees as possible. *Id.*; R. 360, Graham Decl. ¶ 8 ("[T]he conventional wisdom was that closer is better regarding the distance between a talker and a microphone for audio conferencing."); R. 367-1, Giza Exh. 22 at 1 (Shure blog explaining that "to an experienced audio engineer, the ceiling is the last place to mount a microphone. Why? Because it is far away from the desired audio source (the talker) …"). At the same time, popular demand from many audio conferencing users was that microphones *not* be on conference room tables, and that they be as close to out-of-sight as possible. R. 366, Mot. Prelim. Inj. '806 Patent at 22-23 (sealed).[5]

The development of beamforming microphones did not immediately disrupt the traditional view. As the Court explained in its decision denying ClearOne's motion for a preliminary injunction on the '186 Patent,

> Beamforming is a technology that combines signals from multiple microphones in a microphone array to generate combined audio signals (called "beams") that pick up sounds from a particular location. … The advantage of a beamforming microphone is that it can focus in on the sounds that audio-conference participants want to hear (that is, people's voices), while filtering out unwanted sounds (like background noise and paper shuffling).

[5]This Opinion cites to the public, redacted versions of filings when possible ("redacted"), but to the under-seal version of each document when necessary ("sealed"). In certain instances, the Opinion cites to a sealed filing for a general proposition that has been publicly argued or briefed by the parties, but for which some supporting facts are sealed. The public version of this Opinion does not show any redactions in those instances, simply because the general proposition described in the text of the Opinion itself is properly in the public record.

R. 279, Mem. Op. and Order at 3 (cleaned up)[6] (redacted). ClearOne's original beamforming microphone product, the BMA, responded to the traditional view requiring microphones located close to speakers. Because most conferencing users wanted their conferencing microphones off their conference tables, teams at ClearOne first focused on extending their ceiling-mounted beamforming microphone down into the room as far as possible, minimizing the distance between the attendees and the microphone. R. 360, Graham Decl. ¶¶ 8-10 ("ClearOne engineers … spent several months of engineering effort to design a new ceiling mount that would allow the beamforming array to be adjustably positioned as much as 24 inches down from the ceiling in order to be closer to the audio source—the talkers in a room.").

But in the course of product development, ClearOne engineers realized that mounting their BFMA on the ceiling—that is, increasing the distance between the BFMA and the speakers in the room—reduced the quality of the sound it produced *less* than the engineers thought it would. R. 360, Graham Decl. ¶ 9. Their beamforming technology made the audio quality better than the quality a *non*-beaming microphone would achieve when mounted on the ceiling. R. 477, Prelim. Inj. Hrg. Tr. at 76:1-9 (Graham testifying that the "actual test results indicated that the beamforming microphone array actually sounded better than the traditional ceiling microphones that were used at the time."); R. 370, Giza Exh. 10 (sealed) ([redacted]

[redacted]

[6]This opinion uses (cleaned up) to indicate that internal quotation marks, alterations, and citations have been omitted from quotations. *See* Jack Metzler, *Cleaning Up Quotations*, 18 Journal of Appellate Practice and Process 143 (2017).

[redacted]). The next month, ClearOne engineers came up with the idea to integrate a BFMA with a ceiling tile. Prelim. Inj. Hrg. Tr. at 80:25-81:20; R. 360, Graham Decl. ¶ 10. And alas, the '806 Patent came into being.

ClearOne has identified four representative claims of the '806 Patent: Claim 1 is the independent claim, and Claims 4, 5, and 6 depend on it. R. 326-1, ClearOne Am. Alleged Infring. Content. at 1. The preamble to Claim 1 disclosed a BFMA integrated with a ceiling tile as a "single unit where the ceiling tile is used in a drop ceiling mounting configuration." R. 412-1, Patel Exh. 1, '806 Patent Col. 13:12-15. Limitation 1 of Claim 1 requires "a beamforming microphone array that includes a plurality of microphones that picks up audio input signals." *Id*. Col. 13:16-17. Limitations 2 and 3 disclose an acoustically transparent outer surface to the tile through which the BFMA picks up audio input signals. *Id*. Col. 13:18-24. Limitation 4 requires using the integrated tile-BFMA in a "drop ceiling mounting configuration." *Id*. Col. 13:25-26. And finally, Limitation 5 discloses that the BFMA is "coupled to the back side of said ceiling tile and all or part of said beamforming microphone array is in the drop space of the drop ceiling." *Id*. Col. 13:27-30. Dependent Claims 4, 5, and 6 disclose, respectively, that the ceiling tile "comprises acoustic or vibration damping material" (Claim 4); that the "outer surface [of it] comprises a grille" (Claim 5); and that "said outer surface is coplanar with said ceiling tile" (Claim 6). *Id*. Col. 13:38-43.

B. Alleged Infringement

The Shure MXA910 is a beamforming microphone array that "may be mounted to replace a ceiling tile." R. 402, Shure Resp. at 16 (emphasis omitted) (redacted). The MXA910 includes [redacted] placed in a two-foot by two-foot housing. R. 417, Cerra Decl. ¶ 12 (sealed). The array is "sized to align with the grid of a drop ceiling." R. 407, LeBlanc Decl. ¶ 28. ClearOne alleges that Shure's MXA910 practices all the elements of Claims 1, 4, 5, and 6 of the '806 Patent.

II. Standard of Review: Preliminary Injunction Motions

The Patent Act authorizes courts to grant injunctions to prevent violations of patent rights. 35 U.S.C. § 283. To obtain a preliminary injunction, the moving party must show: "(1) a reasonable likelihood of success on the merits; (2) irreparable harm if an injunction is not granted; (3) a balance of hardships tipping in its favor; and (4) the injunction's favorable impact on the public interest." *Amazon.com, Inc. v. Barnesandnoble.com, Inc.*, 239 F.3d 1343, 1350 (Fed. Cir. 2001). On likelihood of success, ClearOne must show that (1) it can likely prove that Shure is infringing the '806 Patent and (2) that the '806 Patent will likely withstand Shure's challenge to its validity. *See Genentech, Inc. v. Novo Nordisk A/S*, 108 F.3d 1361, 1364 (Fed. Cir. 1997). "[A] preliminary injunction is an extraordinary remedy never awarded as of right." *Wind Tower Trade Coal. v. United States*, 741 F.3d 89, 95 (Fed. Cir. 2014) (quoting *Winter v. Nat. Res. Def. Council, Inc.*, 555 U.S. 7, 24 (2008)).

III. Analysis

A. Claim Construction

Before digging into the arguments on infringement and invalidity, the Court must decide what invention the '806 Patent actually claims. Claim construction requires that the Court determine how a person of ordinary skill in the art would understand the claim terms. *Phillips v. AWH Corp.*, 415 F.3d 1303, 1313 (Fed. Cir. 2005) (en banc). The claim's own language is the starting point, but "[c]laims must be read in view of the specification, of which they are a part." *Markman v. Westview Instruments, Inc.*, 52 F.3d 967, 979 (Fed. Cir. 1995). Prosecution history is also "of primary significance" in determining how a claim should be understood. *Id*. at 980. Lastly, extrinsic evidence—that is, expert testimony or any other evidence outside of the patent and prosecution history—can also be considered, but carries less weight than intrinsic evidence. *Id*. at 980-982. Extrinsic evidence is mostly useful for helping the Court to understand the relevant art and to explain how the invention works. *Phillips*, 415 F.3d at 1318-19.

At the preliminary injunction stage, the parties dispute the definition of a person of ordinary skill in the art, as well as the meaning of three terms in the patent's specification and claims: (1) "beamforming microphone array"; (2) "drop space"; and (3) "ceiling tile." *See* '806 Patent Col. 13:12-43. As noted above, this Opinion also considers the additional arguments presented on "beamforming microphone array" and "drop space" in the claim construction briefing and the claim

construction hearing held on July 12, 2019. The Court will take each of those three terms in turn.[7]

1. Person of Ordinary Skill in the Art

The Federal Circuit has set out several factors to help courts determine the level of ordinary skill in the art through which to view claim construction. *Daiichi Sankyo Co., Ltd. v. Apotex, Inc.*, 501 F.3d 1254, 1256 (Fed. Cir. 2007). Those factors include "(1) the educational level of the inventor; (2) type of problems encountered in the art; (3) prior art solutions to those problems; (4) rapidity with which innovations are made; (5) sophistication of the technology; and (6) education level of active workers in the field." *Id*. (cleaned up).

Shure and ClearOne's disagreement in this arena largely comes down to whether a person of ordinary skill would have experience in beamforming, specifically digital signal processing. *See* R. 369, ClearOne Mot. Prelim. Injunction at 8 ("Here, a POSITA would have … at least one year of work experience in the field of digital signal processing.") (redacted); R. 402, Shure Resp. at 9-10 ("The art involved in the '806 Patent is the attachment of a BFMA in a room, and the technology involves basic mechanical or electrical attachments. … One need not have experience in beamforming to accomplish this.") (redacted). The parties' arguments on this point did not change substantively between the preliminary injunction and claim

[7]Later in this Opinion, the Court will also discuss constructions of two new terms raised at the claim construction stage because they overlap with infringement and validity issues for the preliminary injunction decision. *See supra* at 2 n.4.

construction phases. *See* R. 508, Shure Claim Const. Br. at 22-23; R. 520, ClearOne Resp. at 21-22 (redacted).

On review of the competing arguments, the Court concludes that ClearOne is correct that a person of ordinary skill in the art of the '806 Patent should have experience in beamforming, likely by digital signal processing. Shure argues that "the '806 Patent does not disclose or deal with complex beamforming algorithms or teach the design of a BFMA." R. 402, Shure Resp. at 10 (redacted). But the '806 Patent does disclose beamforming—and it discloses somehow integrating a beamforming microphone array with a ceiling tile. A person of ordinary skill looking to practice the '806 Patent would have to figure out how to make that combination work, and that in turn would require understanding digital signal processing.

Practically speaking—and being able to practice the patent is important—ClearOne is correct that most of the current applications of beamforming rely on digital signal processing, and evidence that ClearOne offered in the context of its claim construction argument on "beamforming microphone array" (discussed further below) makes that clear. To resist this, Shure's expert, Wilfred LeBlanc, says that a digital signal processor is not the only "device capable of" performing the operations disclosed in the '806 Patent. R. 407, LeBlanc Decl. ¶ 25. But modern beamformers generally use digital signal processors: one of ClearOne's inventors, Derek Graham, credibly testified that he had never seen an application of beamforming without a digital signal processor, though it might be theoretically possible to create one. Prelim. Inj. Hrg. Tr. at 87:15-89:10. When asked for an example of a beamformer that

does *not* use digital signal processing, Shure pointed to the Miki patent. *Id*. at 40:2-11. ClearOne argues that Miki does not teach beamforming at all.[8] R. 440, ClearOne Reply at 14-15 (redacted). But even if the Miki patent discloses some type of beamforming, there is no evidence that any product currently on the market performs beamforming without DSP.

Given that a person of ordinary skill in the art disclosed in the '806 Patent would need a working understanding of digital signal processing,[9] the Court adopts ClearOne's definition of a person of ordinary skill in the art: the skilled artisan must have at least one year of work experience in the field of digital signal processing.

2. Beamforming Microphone Array

As discussed earlier, the '806 Patent teaches combining a beamforming microphone array (again, commonly referred to in the industry as "BFMA") with a ceiling tile. But Shure and ClearOne disagree on exactly what comprises a "beamforming microphone array." Shure argues that a BFMA is "a plurality of

[8]It is not clear from the Miki patent what type of processor it uses, or whether its inventors would describe it as disclosing beamforming. The invention described in the patent does include "a sound-source position detection means, which detects the position of the sound source based on signals input from the aforementioned multiple sound-collection devices and then selects the input signal from the sound-collection device that is detected as the position of the sound source." R. 412-1, Patel Exh. 13, Claim 1, Lim. 2. It is unclear if this "means" describes a digital signal processor or some other type of signal processor. On the other hand, the patent also states that it does not "focus[] the sound-collection beam on a specific speaker." *Id*. ¶ 0008. So it is simply not clear whether Miki is a good example of a beamforming microphone array without a signal processor.

[9]Shure also argues that "[t]he backgrounds of the inventors of the '806 Patent" also support its definition. R. 402, Shure Resp. at 10 (redacted). But by its own admission both Derek Graham and David Lambert have degrees in electrical engineering—not just experience installing audio equipment. And while Michael Braithwaite has no college degree, he has completed college-level coursework in computer science, physics, and math, as well as computer programming experience. R. 421, Patel Exh. 70, Braithwaite Dep. Tr. at 16:13-17:16 (sealed).

microphones that produce audio signals to be used to form a directional pick up pattern." R. 419-1, Joint Claim Const. Chart. In contrast, ClearOne proposes that a BFMA consists of "microphones coupled together and positioned at predetermined locations that are used with digital signal processing algorithm to form a directional pickup pattern." *Id*. At the preliminary injunction stage, Shure and ClearOne agreed that the relevant difference between their constructions is that ClearOne's, in addition to microphones, includes related hardware that accomplishes the beamforming, while Shure's does not. *Id*. At the claim construction stage, ClearOne highlighted that difference further by proposing to add the words "and related hardware capable of using a DSP algorithm to form a directional pickup pattern" to the end of its construction. R. 520, ClearOne Claim Const. Resp. at 22 (redacted); R. 548, Claim Const. Hrg. Tr. at 44:4-5 (Shure pointing out ClearOne's addition).[10]

The other point of dispute is whether the construction should include the requirement that the microphones in the array are "positioned at predetermined locations." R. 520, ClearOne Claim Const. Resp. at 26-27 (redacted); R. 535, Shure Claim Const. Reply at 11; Claim Const. Hrg. Tr. at 49:2-50:18. The Court will discuss each disagreement in turn.

[10]ClearOne's complete proposal in its claim construction briefing is: "multiple microphones coupled together and positioned at predetermined locations that are used with a digital signal processing ("DSP") algorithm to form a directional pickup pattern, and related hardware capable of using a DSP algorithm to form a directional pickup pattern." R. 520, ClearOne Claim Const. Resp. at 22 (redacted).

a. Digital Signal Processing Hardware

On the issue of the "related hardware," ClearOne essentially argues that the BFMA cannot *be* "beamforming" without a digital signal processor to *do* the beamforming. *See* R. 440, ClearOne Reply at 5 ("Shure proposes a construction … which effectively strips the word 'beamforming' out of this claim term.") (redacted); Claim Const. Hrg. Tr. at 54:3-5 ("The term 'beamforming' is used in this claim over and over again. Shure's claim construction would mean that word just disappeared to no end."). Shure responds by pointing to language in the specification that suggests that a "beamforming microphone" should be construed "in the context of its broadest definition" and that references to the BFMA in the patent refer to "any and/or all devices capable of performing respective operations in the applicable context." R. 402, Shure Resp. at 12 (quoting '806 Patent Col. 4:12-13, 4:25-29) (redacted); R. 407, LeBlanc Dec. ¶ 25 ("While a digital signal processing algorithm might be used to [perform the operations of the '806 Patent], it is not the only 'device capable of' doing so, and should not be read into the claims as a requirement."); Claim Const. Hrg. Tr. at 48:9-11 ("Shure's construction allows for the communication device to be located remotely or also to be contained within the array, because the communication device is not part of the array.").

Shure also argues that beamforming need not even involve digital signal processing. LeBlanc points out that "beamforming does not need to be complicated signal processing, two microphones mounted planar (horizontal) to the ceiling can be used in a broadside delay and sum array, and two microphones placed vertically can

be used in an endfire differential array (cardioid or other simple configuration)." R. 407, LeBlanc Decl. ¶ 22; *see also id.* ¶¶ 21-27 ("Any microphone inherently (e.g., physically) designed to have directional pickup pattern can be described as a beamforming microphone."). Given that the patent requires a broad construction of beamforming, Shure argues, it would be inappropriate to read in a requirement of a digital signal processor or any other hardware at all.

Based on the text and context of the '806 Patent, Shure's construction of "beamforming microphone array" makes more sense than ClearOne's. As noted above, modern applications of beamforming microphones generally rely on digital signal processing to form beams from audio input signals. But even if a person of ordinary skill would assume that the invention claimed in the '806 Patent requires DSP to function, the patent itself does not teach that the DSP is *part* of the BFMA, that it must be in the same location, or even that they must be near each other.

Beginning in Column 4 of the '806 Patent, Graham and the other inventors describe a "first environment," pertaining to Fig. 1A. '806 Patent Col. 4:35. According to the patent itself, that environment could involve "audio conferencing, video conferencing, etc."—essentially, communication "between multiple users located within one or more substantially enclosed areas. *Id.* Col. 4:35-38. That is the embodiment relevant for this motion. The patent describes two different components relevant to how the communication between the different sets of users works: the "beamforming microphone array" (Array), and a "first communication device." *Id.* Col. 5:9-12 ("The first environment 100 may also include a beamforming microphone array

116 (hereinafter referred to as Array 116) interfacing between the first set of users 104 and the first communication device 110 over the network 114."). At this point, the patent describes the Array as including various microphones, possibly a "combination of beamforming microphones … and non-beamforming microphones." *Id*. Col. 5:17-19. Both sets of microphones, unsurprisingly, "capture [] audio input signals." *Id*. Col. 5:20-23.

But in the environment described in Columns 4-6, the Array *itself* does not process those audio signals. Instead, the Array "may transmit the captured audio input signals to the first communication device 110 for processing and transmitting the processed, captured audio input signals to the second communication device 112." '806 Patent Col. 5:24-27. Not only that, the first communication device performs the beamforming: "In one embodiment, the first communication device 110 may be configured to perform augmented beamforming … using a combination of the [beamforming microphones] and one or more [non-beamforming microphones]." *Id*. Col. 5:27-31; Col. 6:3-8 ("[T]he first communication device 110, which is configured to perform beamforming, may be implemented in hardware or a suitable combination of hardware and software, and may include one or more software systems operating on a digital signal processing platform.").

The description above makes clear that the device performing the beamforming (the "first communication device") is conceptually different from the BFMA. That alone is enough to establish that under the terms of the patent the hardware that applies the beamforming algorithm is distinct from the beamforming microphone

array itself. But the patent makes the case even clearer by implying that the "first communication device" could be in an entirely different location from the beamforming microphone array. The patent states that, "[i]n another embodiment, the functionality of the communication device 110 *may* be incorporated into Array 116." '806 Patent Col. 5:44-46 (emphasis added). Similarly, it later states that "[i]n some embodiments, the Array 116 *may* be integrated with the first communication device 110 to form a communication system." *Id.* Col. 6:1-3 (emphasis added). This language implies that the communication device could be totally separate from the Array itself—they need not be incorporated or even located together.[11]

The language in the patent describing the processor as distinct and possibly even distanced from the BFMA fits well with a few different references to digital signal processing in the parties' testimony and exhibits. For example, one of ClearOne's inventors, Michael Braithwaite, acknowledges that digital signal processing for older microphone arrays in the past took place in a rack in a utility closet, for reasons of size and ease of access. R. 421, Patel Exh. 70, Braithwaite Dep. Tr. at 70:6-72:4 (sealed). Now that digital signal processing requires smaller

[11]Of course, at the claim construction hearing, ClearOne argued that while some embodiments in the patent transmit audio signals to a separate communication device, some do not. Claim Const. Hearing Tr. at 53:4-21. Counsel for ClearOne argued, "So Shure complains that ClearOne's claim construction reads out the embodiment in which audio signals are transmitted to another communication device, but ClearOne submits that Shure's proposed construction reads out these other embodiments in which the functionality of the communication device is incorporated into the array." *Id.* at 53:16-21. But that is not quite right. Shure's construction does *not* require that the processing hardware be *included* with the BFMA, but it also does not require that the processing hardware be *excluded* from the apparatus entirely. Excluding the hardware from the definition of BFMA does *not* require it to be located in a separate location.

equipment that can be controlled remotely, it makes sense that processors are more frequently located near the beamforming microphone arrays that they receive inputs from. *See id.*; *see also* R. 409, Cerra Decl. ¶ 14. ("The need for a remotely-located separate processor box would have driven the cost of the product up significantly over today's model.") (redacted). But it was not long ago that processors *had* to be located at a distance from microphone arrays. *Id.* ¶ 14. ("[T]he required processors in 2006 would have generated enough heat to require a separate, remotely-positioned processor box") (redacted). And there is no reason to suppose that the '806 Patent assumes that the BFMA and DSP will be located in the same place. Even one of ClearOne's experts, Paul Waadevig, stated—in the present tense—that "[d]igital signal processing, which includes acoustic echo cancellation, is done in specialized units, usually in a cabinet or otherwise not visible to the end user." R. 362, Waadevig Rep. ¶ 27 (redacted).

At the claim construction stage, ClearOne also argued that that the Court should take a clue from the definition of "array system" in the '524 provisional application. Claim Const. Hrg. Tr. at 54:20-55:4. The relevant excerpt from the provisional is this: "The system includes the following: a beamforming microphone array system; a beamforming array algorithm that uses the beamforming microphone array system; and a mounting method for the beamforming microphone array system." R. 508-11, Claim Const. Exh. B-103, '524 Provisional ¶ 11. ClearOne argues that because "array system" in the '524 provisional includes "the algorithm," the BFMA in the '806 Patent must also include the hardware that implements whatever

algorithm is used to do the beamforming. Claim Const. Hrg. Tr. at 54:20-55:4 ("It makes clear that the beamforming microphone array system includes the beamforming microphone array and the algorithm that uses that array system … So in the 524 provisional, at least, it's clear that the claimed system incorporates the algorithms and itself does the beamforming."). But the language in the provisional is somewhat circular, because it says that the "system *includes* … a … system." R. 508-11, Claim Const. Exh. B-103, '524 Provisional ¶ 11 (emphasis added). Even setting aside that ambiguity, a "system"—which is what the '524 provisional is describing—is not analogous to a "beamforming microphone array." Indeed, it seems that the "beamforming microphone array" is just *part* of the "system." The "algorithm," in turn, is a separate part. If so, the definition of "system" from the '524 provisional is simply further evidence that the algorithm need not be built into the array.[12]

Shure's definition of BFMA recognizes that the processing—digital or otherwise—that accomplishes the beamforming itself need not take place next to or even near the microphones. According to the terms of the patent, as well as the realities of digital signal processing, the array and the processor are two different devices. So Shure's construction of "beamforming microphone array" is the correct one on that issue.

[12]At the claim construction hearing, Shure made an additional argument that the array should include "a combination of beamforming microphones and non-beamforming microphones" and that "reading the definition of beamforming microphone into the array would be unduly limiting." Claim Const. Hrg. Tr. at 44:24-45:4. This appears to be a continuation of Shure's argument that the array itself should not be required to perform beamforming. But ClearOne does not appear to argue the opposite—that the array can *only* include beamforming microphones. And in any case, for the reasons already explained, it is clear that Shure's definition, at least on the issue of the DSP hardware, is the correct one.

b. Predetermined Locations

The other dispute is whether the microphones in the BFMA are required to be at "predetermined locations." R. 508, Shure Claim Const. Br. at 26-27; Claim Const. Hrg. Tr. at 49:22-50:18. Shure argues that including "predetermined locations" in the construction would improperly import a term from Claim 2 into Claim 1, making Claim 2 essentially meaningless. R. 508, Shure Claim Const. Br. at 26-27 (citing '806 Patent at 13:31-33). In response ClearOne argues that using "predetermined locations" in the construction of BFMA would *not* render Claim 2 meaningless, because what Claim 2 really adds is not predetermined locations but instead that the microphones be located "on or in [the] ceiling tile," as opposed to just above it. R. 520, ClearOne Claim Const. Resp. at 26-27 ("Claim 1—as construed by ClearOne—does not require that the microphones are 'on or in' the ceiling tile; the mics could be recessed further into the drop space beyond the ceiling tile.") (redacted). ClearOne explains that the language stipulating that the microphones will be positioned at "predetermined locations" in the array is consistent with other language in the '806 Patent that describes the microphones as "arranged in a specific pattern that facilitates maximum directional coverage," Col. 11:21-23, or "selectively placed at known locations to design a set of desired audio pick-up patterns," Col. 9:53-55. *See* R. 520, ClearOne Claim Const. Resp. at 26 (redacted).

ClearOne has the better argument. The language in support of ClearOne's interpretation comes from the specification, reflects details about the BFMA found throughout the '806 Patent, and is consistent with what a skilled artisan would

understand a microphone array to be. Because the language "positioned at predetermined locations" will likely assist the jury in understanding what the BFMA is and how it works, the Court includes it in its construction.

Ultimately, then, the Court uses most of Shure's construction, leaving the digital signal processor *out* of the BFMA, but adding that the microphones in the array must be "positioned at predetermined locations." The Court thus arrives at the following construction: a beamforming microphone array is "a plurality of microphones positioned at predetermined locations that produce audio signals to be used to form a directional pick up pattern."

3. Drop Space

The '806 Patent claims an invention that puts a beamforming microphone array in the ceiling. In a room with a dropped ceiling, the claimed ceiling tile fits into the drop ceiling grid, and at least some of the array is hidden behind the drop ceiling in what is called the "drop space." The parties disagree on the meaning of "drop space." Although the term is used throughout Claim 1 of the '806 Patent, the parties' dispute centers on its use in Limitation 5, which specifies that the "beamforming microphone array is coupled to the back side of said ceiling tile and all or part of said beamforming microphone array is in the *drop space* of the drop ceiling." '806 Patent Col. 13:27-30 (emphasis added).

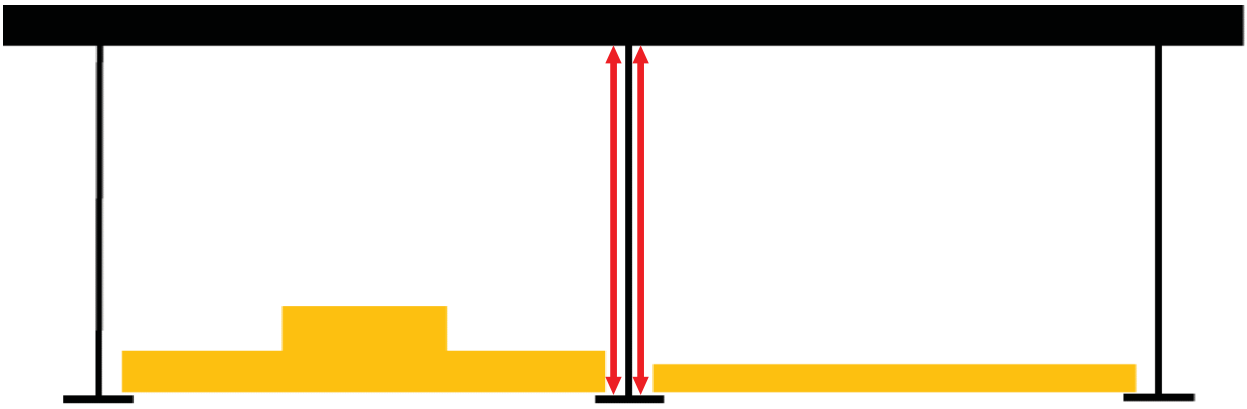
The parties' disagreement on the proper construction of "drop space" comes down to whether the lower boundary of the space is at the back or top of the ceiling tiles that make up the ceiling, or whether it extends to the tiles' lower surface—that

is, the surface facing down into the room. Shure's proposed construction is that the drop space is "the space between the lower surface of the true ceiling of the room and the upper surface (back surface) of the drop ceiling tile." R. 419-1, Claim Const. Chart. Shure argues that the ceiling tiles in a drop ceiling cannot be part of the drop space because the tiles themselves are not "space," and because ceiling tiles are not conventionally understood to be part of the "plenum" (an industry term used to refer to the "open air space from the back surface of the ceiling tiles to the true ceiling above").[13] R. 402, Shure Resp. at 14 (redacted). Initially, ClearOne's proposed construction was that the drop space is "the space between the surface of the structural ceiling of the room and the lower surface of a suspended ceiling tile." R. 419, Claim Const. Chart. In other words, ClearOne believed the drop space should "include[] the space in which a drop ceiling tile rests." R. 440, ClearOne Reply at 7 (redacted). At the claim construction hearing, ClearOne revised its construction slightly to: "the space between the surface of the structural ceiling of the room and a plane defined by the support beams for the drop ceiling." Claim Const. Hrg. Tr. at 74:13-16; *see also* R. 520, ClearOne Claim Const. Resp. at 29 ("Put another way, a

[13]Both parties referenced the "plenum" in their arguments about the drop ceiling. ClearOne argued, for example, that the fact the MXA910 is plenum rated suggests it must be in the drop space. Prelim. Inj. Hrg. Tr. at 25:2-5 ("[H]ere's a document that's describing the MXA910 product, and it talks about it being plenum rated, and it says it has this FyreWrap protection, and it clearly it's talking about it being in the plenum space"). Shure, on the other hand, argued that "drop space" must be the same as the plenum space, and thus have the same definition. *Id*. at 49:8-50:22. The Court did not find arguments about the plenum to be particularly persuasive, given that Shure seems to acknowledge that the term "plenum" is related to ventilation and fire regulations and is not necessarily used in the same context as the '806 Patent. *See, e.g.*, *id*. at 64:24-65:4 ("It's only when you take an electrical device and you're putting it up into the plenum space, the air space, such that it is—has exposure to the air, then it has to be rated as plenum rated.").

'drop ceiling' should be defined by a 'plane,' even when the ceiling tiles have not yet been placed onto the support beams. The ceiling tiles are paced *into* the drop space formed by the support beams; they do not themselves define it.") (redacted).

Based on the text and the context of the '806 Patent, ClearOne's revised construction is correct for the reasons detailed below. For the purposes of this litigation, the Court construes the drop space as the space between the structural ceiling of the room and the plane defined by the drop-ceiling support beams. In a drop ceiling supported by a T-bar ceiling support grid, the drop space will end at the plane of the horizontal bars used in the grid—specifically, in the figure below (originally provided by ClearOne in its preliminary injunction slides), the horizontal lines on which the tiles rest:



The T-bar configuration, which Shure conceded is the typical ceiling configuration in conference rooms using the MXA910, Prelim. Inj. Hrg. Tr. at 47:13-23, helps explain what is understood to be the "drop space" in a room *before* the ceiling tiles are dropped in. A person of ordinary skill in the art would assume that the drop

space is all the space above the horizontal T-bar grid. The lower plane of the drop space does not then change simply because ceiling tiles are placed in it. Shure is, of course, correct that ceiling tiles are not themselves "space." *See* R. 402, Shure Resp. at 14 ("This construction is nonsensical, because the material of the ceiling tiles is not 'space.'") (redacted). But that is not the point: the ceiling tiles are *in* the drop space.

This is clear in the figure above: the yellow components of the image are the tiles themselves; the black bar along the top represents the structural ceiling; the vertical black lines represent the vertical bars of the suspended ceiling; and the short, horizontal black lines at the bottom are the horizontal part of the grid, on which the tiles rest. In the figure, the drop space is not defined by the ceiling tiles but by the T-bar structure on which they rest. The bottom of the structure is the lower boundary of the space.[14]

One potential problem with ClearOne's construction of "drop space" is whether it jibes with the language in Limitation 5 requiring "all or part" of the array to be in the drop space. Under ClearOne's construction, it is easy to envision what it would look like for *all* of an array to be in the drop space—anything integrated with the ceiling tile that does not extend below it would be within the drop space. But it is more difficult to envision how only *part* of the array would be in the drop space. Under Shure's construction, the possibility of only "part" of the array existing in the drop

[14]As a side note, ClearOne argues that the drop space must extend to the bottom of the tiles because there is air between the tiles, presumably touching the sides of the tiles themselves. R. 440, ClearOne Reply at 7 (redacted); Prelim. Inj. Hrg. Tr. at 18:17-19:11. That argument is not convincing—*where* air can be found is not a useful limiting principle for the drop space, because air could be found in any small nook or cranny.

space is more obvious—the part of the array that is within the ceiling tile (or below its back surface) would not be in the drop space, while any part extending above the back surface of the tile would be. Shure pointed this out in the preliminary injunction hearing. Prelim. Inj. Hrg. Tr. at 47:5-7 ("[I]f the lower surface of the ceiling tile is the boundary, wouldn't the beamforming array always be all in the drop space?").

In grappling with this issue, at the preliminary injunction hearing, the Court asked one of the inventors of the '806 Patent, Derek Graham, "what would be an example of a situation where the array would be just in part of the drop space?" Prelim. Inj. Hrg. Tr. at 90:1-3. Graham responded that it could be possible for the "front surface, the acoustically transparent outer surface" to be "lowered somewhat to allow the microphones to be dropped down a little bit into the room." *Id*. at 90:7-10. Graham testified that the integrated array-and-ceiling tile in that scenario would either be lower than the other tiles in the room, or "lower than just the support grid." *Id*. at 90:11-15. Under ClearOne's proposed construction of "drop space" it is uncertain how the microphones would be only partly in the drop space if *all* the tiles in the room were lowered slightly below the support grid, and the microphones were above them. But the possibility remains that the tile practicing the patent could be lower than the *rest* of the tiles in the room, in which case microphones directly above that tile could be only partly in the drop space. And that possibility might still be aesthetically superior to the current BMA-1 ceiling mount. ClearOne reiterated that point at the claim construction hearing by presenting a slide that illustrated how a

product practicing the patent could have a lower surface *below* the plane of the drop ceiling but still leave room for part of the array to be located above that plane:

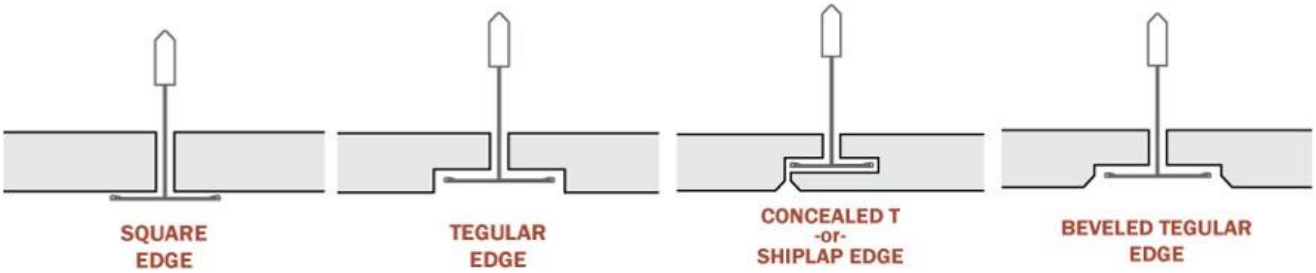
See also Claim Const. Hrg. Tr. at 72:19-73:4. In the image above, the middle tile is integrated with a BFMA, which could be located partially below the plane of the ceiling and partially above it—that is, partially in the drop space.

In response to this, Shure argues that a definition that allows a product that descends into the room (as in the image above) would create an invalidity problem, so the definition must be wrong. *See* Claim Const. Hrg. Tr. at 67:4-18. But Shure's argument is not quite right—at least not with regard to Chhetri as prior art (Chhetri is discussed further below). Here is why: a BFMA that is not in the drop space at all—and is instead located *totally* beneath it, like Chhetri—would not practice Limitation 5 of Claim 1 of the '806 Patent, and thus would not be covered by the patent. But ClearOne's construction does not require that here—the example image above shows a BFMA that is both *in and below* the drop space. So even under ClearOne's construction, it is still plausible that Limitation 5 was added in response to the

Examiner's concern about the Chhetri patent, exactly as Shure has argued. *See* R. 402, Shure Resp. at 8 (redacted). And ClearOne's construction does not interfere with that balance at all: Limitation 5 (by Shure's argument) vitally differentiates the '806 Patent from Chhetri. Of course, a product like the middle tile in the image might face a different set of invalidity challenges than a version of the product that lines up perfectly with all the other tiles in the room, and perhaps Shure will present some arguments to that effect at the summary judgment stage. But at the very least, it is safe to say that the image provided by ClearOne shows a BFMA unlike Chhetri both in that it is (1) partly in the drop space, not dangling totally into the room, and (2) *integrated with* a ceiling tile—not just hanging from it.

Relatedly, ClearOne's construction is also a better fit with the context of the '806 Patent. If the goal of the patent was to get microphones mostly out of sight of the people in the room, it does not matter whether they are located above the *top* side of a drop ceiling tile—as long as they are above the bottom of it—despite Shure's protestations to the contrary. *See* Claim Const. Hrg. Tr. at 68:6-12.

Three other arguments raised by Shure at the claim construction phase are worth addressing. First, Shure points out that not all drop ceiling tiles sit in drop ceiling support grids quite the same way, using this image to illustrate the point:



See Claim Const. Hrg. Tr. at 69:6-12. Shure argues that because of this diversity of beam-and-tile configurations, relying on the beam to define the drop space creates confusion. *Id.* But it is not clear why that would be, because it does not appear to matter to any of the litigated issues exactly *how* the tile sits in the beam. A BFMA integrated with any of the tiles shown above could sit either totally or partly in the drop space. It is true that in the case of a tegular, shiplap, or beveled tegular edge, the starting point of the drop space depends on how the term is interpreted. But there is nothing wrong with that (and it is true for the square edge model, too)—if anything, the diversity of tiles actually makes it more sensible to define "drop space" by referring to support beams that, by physical necessity, are always part of a drop ceiling.

Second, Shure has argued that the support beams should not be used as a reference point in defining the drop space because the support grid itself does not create the ceiling. Claim Const. Hrg. Tr. at 69:22-70:2 ("And this notion that the grid or the support beam in any way should be considered the drop space doesn't make sense. Without the ceiling tiles, the grid just creates openings of infinite space. It doesn't create any type of a boundary."). But of course, no one is arguing that support beams create a ceiling all by themselves if there are no ceiling tiles installed on them. What the beams do is create the boundary of the drop *space*, which after all, is just space—not the ceiling. Shure's argument relies on the fallacy of singling out one piece of the overall system and then challenging it as non-sensical when divorced from all

of the other pieces. Protesting that the beams do not create a ceiling without tiles is just as wrong as pointing to a ceiling tile that is not installed, just lying on the floor, and saying, "That's not a ceiling tile, it's a floor tile."

Third, at the claim construction hearing, Shure encouraged the Court to think about the ceiling as the equivalent of a wall (albeit a horizontal one) between two rooms. Claim Const. Hrg. Tr. at 70:11-20 ("[I]f a skilled artisan wanted two rooms … and wanted to put a partition in the middle … [t]hat thickness of the partition should not be attributed to either room."). But a drop ceiling is not a wall, and drop space is not a room. As ClearOne points out, the drop space consists of "space"—it need not all be "useful space." *Id.* at 71:4-6; *see also id.* at 70:15-17 (Shure arguing that the wall thickness "should not be attributed to either room, because it does not provide any useful space."). Regardless of the thickness of the tiles used in a drop space, they are *in* the space—they do not define it.

4. Ceiling Tile

Both Shure and ClearOne agree that "ceiling tile" should have its plain and ordinary meaning. R. 402, Shure Resp. at 11 (redacted); R. 440, ClearOne Reply at 4-5 (redacted). The Court agrees. The Court also notes that the plain and ordinary meaning of the term "ceiling tile" is not limited in terms of the material from which the tile is made. Shure argues that the tile must denote a "standard" ceiling tile, R. 402, Shure Resp. at 11 (redacted), "made from a mineral fiber or other material[with] a high noise reduction coefficient," R. 406, Roy Decl. ¶ 42. But even Shure's expert, Kenneth Roy, acknowledges that "[c]eiling tile[s] come in a variety of textures

and designs," *id.*, and the '806 Patent does not limit the definition of "ceiling tile" further. The one exception, of course, is Claim 4 of the patent, which requires that the ceiling tile "comprise[] acoustic or vibration damping material." '806 Patent Col. 13:38-39. Ultimately, though, Claim 1 does *not* require a specific type of material.

B. Infringement

With claim construction in place, the next question is infringement. In order to show entitlement to a preliminary injunction, ClearOne must demonstrate that it will likely be able to prove that Shure is infringing the '806 Patent. *Amazon.com*, 239 F.3d at 1350. Shure argues that ClearOne cannot do so because the MXA910 does not practice all the limitations of Claims 1, 4, 5, and 6. ClearOne (of course) contends that it does.

1. Whether the MXA910 is Integrated with a Ceiling Tile

Shure argues that the MXA910 does not practice Claim 1 of the '806 Patent because although the MXA910 "may be mounted to *replace* a ceiling tile, it is not *integrated into* a ceiling tile." R. 402, Shure Resp. at 16 (redacted). To counter Shure's argument, ClearOne and its expert both point to internal Shure documents that refer to the MXA910 as a "ceiling tile" or as somehow capable of being integrated into a ceiling tile configuration. R. 439, ClearOne Reply at 9 (sealed); R. 372, Schonfeld Decl. at 8-9 (redacted); *see, e.g.*, R. 370-1, Giza Exh. 18 at 69 [redacted] (sealed); R. 370-13, Giza Exh. 120 at 1 [redacted] (sealed).

Shure's argument here is unconvincing: the MXA910 is indeed a beamforming microphone array integrated with a ceiling tile. The fact that it may not look like every other ceiling tile in a given room does not matter. The bottom line is that it fits the plain meaning of a "ceiling tile," that is, a tile that forms part of the boundary between the drop space and the rest of the room.

At the preliminary injunction hearing, Shure argued that ClearOne's allegations of *how* the MXA910 was integrated with a ceiling tile had changed over time. Prelim. Inj. Hrg. Tr. at 58:25-59:6 ("ClearOne's late-filed newest argument as of just last week is that the MXA910 includes a metal ceiling tile with an acoustically transparent grille pattern. … This was the first time this was introduced. Until now they have referred to the entire device[.]"); *id.* at 61:19-22 ("[P]art of our contention has been you can't say, you have to tell us what is the ceiling tile because from that, we can define some other things, right, that are claim limitations."). But Shure misses the point. The MXA910 is a BFMA in the form of a ceiling tile—ClearOne does not have to point to one particular component of the MXA910 as the ceiling tile, distinct and separate from the beamforming microphone array. That is the point of the invention: they are *integrated* together.

On a similar note, at the claim construction stage, Shure also argued that the relevant language from Claim 1 ("said beamforming microphone array integrated into said ceiling tile as a single unit)," '806 Patent Col. 13:20-21, should be construed as "two separate structures (a beamforming microphone array and a ceiling tile) combined together to form a single unit." R. 508, Shure Claim Const. Br. at 27-29;

Claim Const. Hrg. Tr. at 57:5-64:9. This argument—which mirrors Shure's infringement argument about the supposed lack of integration—hinges on interpreting the claim language to mean that the apparatus must start with both a standalone ceiling tile and a standalone BFMA, and then fastening them together through some mechanical means. R. 508, Shure Claim Const. Br. at 27-29. In support of that argument, Shure says, the patent uses the word "combining" several times to describe the types of features of a room that could be combined with a BFMA. *See id.* at 27-28 (citing '806 Patent Cols. 6:41-60, 6:61-8:24, 8:25-10:8, 10:9-11:15 (describing a combination of a BFMA with a spanner post, lighting fixtures, ceiling tile, and wall panel)). The idea is that in order to "combine" or "integrate" a BFMA with something else, the two items must start out as a separate structures. R. 508, Shure Claim Const. Br. at 28 ("Such combinations necessarily require two structures brought together."). Shure also points to intrinsic evidence that the process of combining the ceiling tile with the BFMA was meant to be mechanical—involving "hooks" or "fasteners." *See id.* (citing '806 Patent Col. 9:5-25 ("The reverse side 270 of the ceiling tile 264 may include hooks … for securing the Array 116 to the ceiling tile 264.")); Claim Const. Hrg. Tr. at 59:12-15.

But Claim 1 speaks for itself. Its plain and ordinary language requires that "a beamforming microphone array [be] integrated into [a] ceiling tile as a *single unit*," '806 Patent Col. 8:20-21 (emphasis added), and that is readily understandable to a skilled artisan that the BFMA and the ceiling tile together form a single unit. The plain and ordinary language does not set limits on *how* the "single unit" must be

created—or how the integration between the ceiling tile and the BFMA must be achieved. And that is not a problem, because Claim 1 is *not* a *method* of manufacturing claim. *See* R. 508, Shure Claim Const. Br. at 15 (acknowledging that Claim 15 is a "method-of-manufacture" claim, but never arguing that Claim 1 should be understood that way). Also, as ClearOne points out, while the patent does discuss embodiments created by combining two separate structures, *see* '806 Patent Col. 8:58-63 ("In one embodiment, the ceiling tile 264 may include a geometrical socket … having an appropriate dimension to substantially receive the Array 116, which integrates the tile and the Array as a standalone unit."), it explicitly states that the process can happen "in a variety of ways," *id.* Col. 8:58-59; *see also* Claim Const. Hrg. Tr. at 63:8-64:7. Another way to do it, according to the patent, is by "integrat[ing] [] the ceiling tile 264 [with the Array 116] as a single unit." '806 Patent Col. 9:26-27.

It is true, as Shure argues, that in the first embodiment (Column 8:58-63) there could be a concern about "damage to the ceiling tile 264 due to the load or weight of the Array 116." '806 Patent Col. 9:27-29; R. 535, Shure Claim Const. Reply at 12; Claim Const. Hrg. Tr. at 61:3-10 ("You're only worried about damage on the one object due to the other object when you are, in fact, combining two separate objects."). But according to the language of the patent itself, one of the reasons to choose the second embodiment—in which the tile and BFMA are integrated into a single unit instead of one structure receiving the other as described in the first embodiment (Col. 8:58-63)—is that "[s]uch [integrated] construction of the unit may be configured to *prevent* any damage." '806 Patent Col. 9:27-29 (emphasis added). So Shure's argument for

reading the two embodiments together actually points in the other direction—the second, integrated embodiment ('806 Patent Col. 9:26-27) is an alternative to the first, separate-structures embodiment ('806 Patent Col. 8:58-63)—an alternative that might alleviate at least one potential issue with using two separate structures as the starting point for manufacturing.

All that said, the point remains that Claim 1 is not a method of manufacturing claim, so it does not set limits on exactly *how* the ceiling tile and BFMA must be integrated, much less require that they start as two separate structures. The Court will rely on the plain and ordinary meaning of this language, which the MXA910 clearly practices.

2. Whether the MXA910 Includes Microphones in the Drop Space

Shure argues that no part of the MXA910 is in the drop space of the drop ceiling, as claimed by the '806 Patent at Claim 1, Limitation 5. R. 402, Shure Resp. at 17-18 (redacted). Because the lower boundary of the drop space is the plane defined by the support beams for the drop ceiling (see above), any MXA910 mounted in the drop ceiling grid practices Limitation 5 of Claim 1.

3. Whether the MXA910 Includes Acoustic or Vibration Damping Material

Finally, Claim 4 of the '806 Patent teaches the invention according to Claim 1, "wherein said ceiling tile comprises acoustic or vibration damping material." Shure argues that the MXA910 does not practice Claim 4, because it does not "include[] the required acoustic vibration or damping material." R. 402, Shure Resp. at 19 (redacted). ClearOne responds by pointing to seven "vibration damping pads" inside the MXA910, referred to in the preliminary injunction hearing as "poron

marshmallows." R. 440, ClearOne Reply at 9 (redacted); Prelim. Inj. Hrg. Tr. at 26:23-28:14. ClearOne's expert Schonfeld points to the pads circled in red on the figure below and identifies them as "vibration damping pads." R. 372, Schonfeld Decl. ¶ 49 (redacted).

ClearOne also points to an internal Shure email [redacted] R. 389-1, Giza Exh. 132 at 5 (sealed); R. 439, ClearOne Reply at 9 (sealed).

Shure contests the function of the gray pads pictured above. David Cerra, Shure's Associate Vice President of Engineering for Conferencing and Audio Processing, stated in his declaration that [redacted] R. 417, Cerra Decl. ¶ 13 (sealed). Instead, he claims, [redacted] *Id.* (sealed). Cerra

also contends that [redacted] According to Cerra, [redacted] R. 417, Cerra Decl. ¶ 13 (sealed). The MEMS microphones used in the MXA910, because they are "poor mechanical transducers," turned out not to require "mechanical isolation." R. 409, Cerra Decl. ¶ 13 (redacted). Cerra's account maps onto at least one Shure internal slideshow document that states [redacted]" R. 370-10, Giza Exh. 110 at 3 (sealed). But the presentation continues: [redacted] *Id.* (sealed). [redacted]

In the end, Cerra never averred that the seven pads identified by Schonfeld are not foam pads, and there is no evidence that they were removed before production—in fact they could not have been (at least not universally), because ClearOne obtained this version of the MXA910 by purchasing it. All of the circumstantial evidence shows that the pads within the red circles identified by Schonfeld are made of foam or some other vibration-damping material. Whether or not they are necessary for acoustic dampening, or whether Shure placed them on the

board for that purpose, is irrelevant. If the material dampens, as this does, then it practices Claim 4.

C. Validity

Next up is the question of the '806 Patent's validity. This is a crucial question. Under 35 U.S.C. § 282 an issued patent "shall be presumed valid." 35 U.S.C. § 282. But if Shure can demonstrate a "substantial question" of the patent's validity, then the preliminary injunction cannot issue. *Amazon*, 239 F.3d at 1350-51. A substantial question exists if the challenger raises an invalidity defense that the patentee cannot prove lacks substantial merit. *Id.* (citing *Genentech*, 108 F.3d at 1364). The Court will address each of Shure's major invalidity arguments.

1. Anticipation

Shure argues that an audio conferencing system produced by the Conference Technology Group, LLC (CTG) anticipated the invention claimed in the '806 Patent. The parties refer to the system as the "CTG System," and the Court will do so too. A "single prior art reference" anticipates a patent, making it invalid, if it "discloses each and every limitation of the claimed invention." *Schering Corp. v. Geneva Pharms.*, 339 F.3d 1373, 1377 (Fed. Cir. 2003). Shure argues that the CTG System includes a BFMA, a BFMA integrated into a ceiling tile as a single unit, and "at least a portion of the BFMA in the drop space." R. 402, Shure Resp. at 20 (redacted).

ClearOne offers several arguments in response. First, ClearOne argues that the CTG System includes a mixer box that is not "integrated with a ceiling tile as a 'single unit.'" R. 366, Mot. Prelim. Inj. '806 Patent at 12 (sealed). Second, ClearOne

argues that the microphones in the CTG are individual and not sold or produced as part of an array, such that they cannot be part of a BFMA as required by the '806 Patent. *Id.* (sealed). Relatedly, ClearOne argues that the CTG System does not actually perform beamforming at all. *Id.* at 12-13 (sealed).

On review of the evidence, the Court concludes that the CTG System does not anticipate the '806 Patent. First, the CTG System is not an array. Shure argues that "having more than one CM-01 on a ceiling tile forms a BFMA integrated into the ceiling tile as a single unit." R. 402, Shure Resp. at 20 (redacted). But there is no evidence that more than one CM-01 has ever been used on a ceiling tile. CTG's CM-01 is *one* microphone, and while Shure argues that consumers *could* combine several of the CTG microphones together, Prelim. Inj. Hrg. Tr. at 95:16-21, ClearOne points out that there is no evidence anyone has ever done that—much less in the space of a single ceiling tile, R. 440, ClearOne Reply at 10 (redacted). And it is not clear *why* a consumer would do that. In fact, CTG advertised that the system could "[p]rovide[] even pick up for the maximum number of participants with the minimum number of microphones," R. 405-5, Newman Decl. Exh. E at 1 (redacted), and that each "CTG microphone has a pickup range with a radius of up to 10 feet or more," R. 405-6, Newman Decl. Exh. F at 9 (redacted).

Second, the CTG System is not "integrated with a ceiling tile," as required to practice Claim 1 of the '806 Patent. Instead, it is installed by drilling a hole in an existing tile and "[p]ushing [the] microphone barrel … through [the] hole in [the] tile until [its] lip stops against [the] tile." R. 405-9, Newman Decl. Exh. I (redacted). It is

then secured atop the tile with a friction clip. *Id.* (redacted). The product is not a ceiling tile combined with a beamforming microphone array but simply a microphone that can be inserted into a ceiling tile. Shure's anticipation theory fails.[15]

2. Obviousness

Under 35 U.S.C. § 103, a proposed patent must not be granted if the claimed invention would have been obvious before the filing date to a person of ordinary skill in the art. To evaluate obviousness, courts consider the scope and content of the prior art, the differences between the prior art and the claims at issue, and the level of ordinary skill in the art, as well as secondary considerations like commercial success, long-felt need, and the failure of others to arrive at the invention. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 417-18 (2007); *Graham v. John Deere Co.*, 383 U.S. 1, 17-18 (1966).

Shure divides its prior art references into two categories. The first is "[r]eferences that disclose beamforming microphone arrays integrated with a ceiling." R. 399-1, Shure Am. Final Inv. Content. at 8. And the second is "[r]eferences that replace a ceiling tile in a drop ceiling with sound collection equipment." *Id.* at 14.

[15]On ClearOne's argument that the CTG System does not performing beamforming, ClearOne points primarily to an admission from Joseph Marash, an employee of the company that created the processor for the CTG System: [redacted] R. 370-8, Giza Exh. 94 (sealed); *see also* R. 368, Schonfeld Decl. ¶¶ 57-58 (explaining that the CTG System's mixers "do not perform a beamforming algorithm to form a directional pickup pattern using multiple microphone inputs") (sealed). Naturally, Shure disagrees, pointing primarily to testimony from LeBlanc that the simple mixing performed by the CTG System satisfies the "broad" definition of beamforming disclosed in the '806 Patent. *See* R. 402, Shure Resp. at 21 (citing R. 407, LeBlanc Decl. ¶¶ 30-36) (redacted). The Court does not need to reach this question given how clear it is that the CTG System is not an array and is not integrated with a ceiling tile.

Shure advocates a sort of mix-and-match approach. By pairing a reference from the first category with a reference from the second category, Shure argues, a person skilled in the art could create a product that practices all the representative claims of the '806 Patent. *Id.* at 22. These combinations would then make the '806 Patent obvious. *Id.*

In determining whether Shure's proposed combinations render the '806 Patent invalid, the Court must examine whether it would have occurred to a skilled artisan to combine the elements of these prior art references with one another in the first place. *ActiveNetworks, Inc. v. Verizon Comms., Inc.*, 694 F.3d 1312, 1327 (Fed. Cir. 2012) ("To invalidate a patent claim based on obviousness, a challenger must demonstrate by clear and convincing evidence that a skilled artisan would have been motivated to combine the teachings of the prior art references to achieve the claimed invention, and that the skilled artisan would have had a reasonable expectation of success in doing so.") (cleaned up); *KSR, Int'l*, 550 U.S. at 418 ("[A] patent composed of several elements is not proved obvious merely by demonstrating that each of its elements was, independently, known in the prior art. … [I]t can be important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the elements in the way the claimed invention does."). In doing so, the Court must be careful to "guard against slipping into use of hindsight" and the "temptation to read into the prior art the teachings of the invention in issue." *Graham*, 383 U.S. at 36 (cleaned up). The Supreme Court has warned, however, that identifying a motivation for a skilled artisan to combine elements of prior art should

not require a rigid test, and a qualifying motivation can be provided by "design incentives or other market forces," *KSR, Int'l*, 550 U.S. at 417-19. Often whether a combination is obvious will come down to whether it "yield[s] predictable results." *Id.* at 416.

None of Shure's proposed combinations make the '806 Patent obvious. All of Shure's proposed combinations involve combining a microphone with a loudspeaker located in a ceiling tile. Shure's combinations feature three different loudspeaker devices: IPSCM Ceiling Tile IP Speaker produced by Advanced Network Devices (AND), the I128SYSM IP Compliant Loudspeaker with Microphone produced by Atlas, and the I-Ceilings tile developed by Armstrong. *See* R. 403, Donahoe Decl. (describing the IPSCM Ceiling Tile IP Speaker) (redacted); R. 402, Marlin Decl. (describing the I128SYSM IP Compliant Loudspeaker with Microphone) (redacted); R. 406, Roy Decl. ¶¶ 119-20 (describing the I-Ceilings device). Shure argues that the loudspeaker devices "provide[] concealment, ease of installation, and maximization of room space." R. 402, Shure Resp. at 24 (redacted). The idea is that adding a BFMA to a loudspeaker that is integrated into a ceiling tile would reap the same aesthetic rewards of the '806 Patent and practice all its claims.

It is not at all clear that a skilled artisan would have been motivated to combine any of the loudspeaker prior art references with a BFMA. ClearOne argues that the objectives of loudspeakers are different than those of audio conferencing microphone arrays, and explains that while "an ideal loudspeaker would transmit sound equally well to everyone in the room … (less directional) … an ideal microphone

would pick up only the active talker and ignore others so that only the active talker is heard (more directional)." R. 369, Mot. Prelim. Inj. '806 Patent at 17-18 (redacted); R. 372, Schonfeld Decl. ¶¶ 87-89 (redacted). The Court agrees: given the differences in the applications of the two types of devices, a person of ordinary skill might very well not have thought to combine them. Shure points out that that the IPSCM, Atlas, and I-Ceilings devices all include microphones or have the capability to receive audio signals. R. 403, Donahoe Decl. ¶ 3 (explaining that the IPSCM product "features a built-in microphone and speaker that allow for two-way communications") (redacted); R. 402, Marlin Decl. ¶ 7-8 (explaining that the Atlas product "includes a single omnidirectional electret condenser microphone … [that] allows for two-way communication with any PC or IP phone.") (redacted); R. 406, Roy Decl. ¶ 120 ("While the I-ceiling speaker is marketed primarily as a loudspeaker, it is also advertised in its brochures, and in US Patents, as useful for direct use in a 'Talk Back' enabled DSP system as a microphone."); *see also* R. 402, Shure Resp. at 23-24 (redacted); *but see* R. 372, Schonfeld Decl. ¶ 68 (disputing whether I-Ceilings is or has a microphone) (redacted). But Shure never argues that the products have particularly high audio quality, or that the microphones are anything more than an attractive add-on to inventions that are mainly used for *hearing* information—not delivering it back. There is no suggestion that the loudspeaker/microphone combinations are similar in design or use to the type of products commonly used in audio conferencing settings.

And even if—given the superior aesthetics of the existing loudspeakers—a skilled artisan would have had a motivation to combine them with a BFMA, there is

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no reason to believe that the skilled artisan would have had any expectation of success. As discussed above, the context for the ’806 Patent was a world in which conferencing microphones usually were not installed in the ceiling. *See* R. 440, ClearOne Reply at 13 (redacted). Inventors and integrators believed that placing microphones as close as possible to the talker was necessary for the type of audio quality the market demanded. R. 360, Graham Decl. ¶ 8; R. 367-1, Giza Exh. 22 at 1; R. 372, Schonfeld Decl. ¶ 26 (redacted). And Graham explained that his team was surprised by the quality of audio they were able to create in their first tests. *See* Prelim. Inj. Hrg. Tr. at 76:1-9 (Graham testifying that the “actual test results indicated that the beamforming microphone array actually sounded better than the traditional ceiling microphones that were used at the time.”); R. 370, Giza Exh. 10 (sealed); R. 360, Graham Decl. ¶ 9. Against this evidence, Shure has failed to show that the results of ClearOne’s tests should have been predictable.

Of course, Shure argues that the audio quality of its proposed combinations is irrelevant, because the ‘806 Patent does not require a certain level of quality. R. 402, Shure Resp. at 27 (“The claims are silent as to quality or conferencing, and could be just as easily practiced by a lower quality voice recognition system for use in a residential application as they could by a professional conferencing system.”) (redacted). But the context of the ’806 Patent is illuminating here, as is the fact that according to its own terms the patent is responding to the traditional method of configuring beamforming microphone arrays. ’806 Patent Col. 1:51-54. ClearOne has produced significant evidence that the traditional method of installing beamforming

microphones—that is, installing them somewhere in the room *below* the drop ceiling (like on the conference tables)—prevailed for so long precisely because of concerns about quality. *See* R. 360, Graham Decl. ¶ 8; R. 367-1, Giza Exh. 22 at 1; R. 372, Schonfeld Decl. ¶ 26 (redacted). In context, the '806 Patent is responding to the problem of the competing needs for attractive aesthetics and high audio quality in the installed audio conferencing market. The motivations of a skilled artisan working in that market and responding to those market pressures would obviously take audio quality into account. So Shure's arguments that quality should not be taken into account at all in the obviousness analysis is unpersuasive.

Rejecting combinations that require combining microphone arrays with loudspeakers knocks out all of Shure's possible combinations: IPSCM plus Sasaki, IPSCM plus Soda, Atlas plus Chhetri, IPSCM plus the BMA-1, IPSCM plus Miki, IPSCM plus Chhetri, and I-Ceilings plus Chhetri. There are other reasons why many of these combinations fail to make the '806 Patent obvious. For example, many of the devices would be quite difficult to combine. Chhetri's proposed array seems to be larger than what would easily map onto a two-foot by two-foot ceiling tile such that attempting to simply combine it with ceiling tile loudspeaker art would involve changing it substantially. *See* R. 440, ClearOne Reply at 13-14 (redacted). Miki is similar: it discloses locating microphones all around a room—not in one location behind one tile. R. 412-1, Patel Exh. 13, Claim 1 (disclosing "[m]ultiple sound-collection devices dispersed over a ceiling or a wall so as to collect sound within the respective prescribed areas."). Combining Miki with a loudspeaker ceiling tile would

seem to involve distorting it beyond recognition. And some of the combinations might be even less obvious because the microphones involved were developed for entirely different purposes. Chhetri was developed for use in an augmented reality system, for example. R. 372, Schonfeld Decl. ¶ 80 (redacted). Soda and Sasaki are both intended for use in home voice-command systems. *Id*. ¶¶ 78, 81-85 (redacted).

ClearOne next points to the secondary considerations of the obviousness inquiry, which include commercial success, long-felt but unsolved need, and the failure of others to arrive at the invention. *KSR, Int'l*, 550 U.S. at 399. Secondary considerations are only a part of the analysis, but here they generally weigh against finding a substantial question of the '806 Patent's validity. Again, ClearOne has pointed to a long-felt need for more remote and aesthetically discreet audio conferencing microphones. *See* R. 362, Waadevig Rep. ¶ 31 ("[E]nd users have long sought microphones that are remote from conference participants and functionally invisible to them. But because microphones are notorious for producing lower quality audio when placed farther away, vendors in the installed audio conferencing market have long struggled to meet this demand.") (redacted); *see also* R. 360, Graham Decl. ¶ 8; R. 367-1, Giza Exh. 22 at 1; R. 372, Schonfeld Decl. ¶ 26 (redacted). And it is indisputable that Shure's MXA910 has enjoyed commercial success, likely at least in part because of its infringing features—an issue the Court will address further below. *See* R. 439, ClearOne Reply at 18 (sealed).

For all these reasons, Shure has failed to raise a substantial question of the '806 Patent's non-obviousness.

3. Arguments under 35 U.S.C. § 112

At the preliminary injunction stage, Shure makes three primary arguments that the ’806 Patent is invalid under 35 U.S.C. § 112 because the patent’s terms are either indefinite or lack a written description. On indefiniteness, a patent is invalid “if its claims, read in light of the specification delineating the patent, and the prosecution history, fail to inform, with reasonable certainty, those skilled in the art about the scope of the invention.” *Nautilus, Inc. v. Biosig Instruments, Inc.*, 572 U.S. 898, 901 (2014). As to lack of written description, 35 U.S.C. § 112(a) requires the specification of the patent to “contain a written description of the invention.” 35 U.S.C. § 112 (a). The Federal Circuit has explained that the “essence of the written description requirement is that a patent applicant, as part of the bargain with the public, must describe his or her invention so that the public will know what it is and that he or she has truly made the claimed invention.” *Quake v. Lo*, 928 F.3d 1365, 1373 (Fed. Cir. 2019) (cleaned up). “The purpose of the written description requirement is to prevent an applicant from later asserting that he invented that which he did not.” *Id.* (cleaned up). As discussed next, none of Shure’s arguments raises a substantial question of the ’806 Patent’s validity.

a. Claim 1

First, Shure argues that the term “drop space” in Limitation 5 of Claim 1 is indefinite and lacks a written description. R. 399-1, Shure Am. Final Invalidity Content. Exh. 1 at 36-37; R. 402, Shure Resp. at 29-30 (redacted). Shure’s argument has to do with ClearOne’s addition of the term “drop space” to the patent. R. 399-1, Shure Am. Final Invalidity Content. Exh. 1 at 36-37. ClearOne added the term to the

dependent claims in June 2017 and attempted to add it to the specification at the same time. *Id*. But the term was not added to the specification until after the patent issued and ClearOne filed a Certificate of Correction. *Id*. Before the term was added to Claims 1, 8, and 15, the limitation already disclosed that the array would be "coupled to the back side of [the] ceiling tile." '806 Patent Col. 13:27-28. Shure contends that because the patent only issued after the addition of the disclosure that "all or part of [the] beamforming microphone array [would be] in the drop space," there must be some difference between the "coupled to the back side" language and the language locating the array in the drop space. R. 399-1, Shure Am. Final Inv. Content. Exh. 1 at 36-37 ("This distinction indicates that there is a difference between the 'back side' of the ceiling tile, and the start of any 'drop space.' However, the specification does not indicate what that difference is."). Shure argues that because the '806 Patent is not clear about what that difference is, Limitation 5 of Claim 1 is indefinite and lacks a written description.

There are two problems with Shure's argument. First, the claim construction of "drop space" adopted by the Court, as detailed earlier in this Opinion, is not dependent on the back side of the ceiling tile. In other words, Shure's argument is premised on Shure's proposed construction of "drop space"—but that construction was rejected. Second, there is no real conflict between language that describes the BFMA as being all or in part in the "drop space" and language that describes the BFMA as "coupled to the back side" of the ceiling tile. Those terms play different roles in describing the invention. For its part, the term "coupled to the back side" describes

where and how the array is attached to the rest of the tile. In contrast, "all or part in the drop space" refers to how the BFMA is positioned in relation to the drop space. The terms are not so redundant that the patent is indefinite or lacks a written description.

b. Claim 5

Second, Shure argues that Claim 5 is invalid for lack of written description. R. 399-1, Shure Am. Final Inv. Content. Exh. 1 at 44; R. 402, Shure Resp. at 30 (redacted). Shure's argument about Claim 5 is that the term "grille," which was added as an amendment to the specification in March 2017 and as a new claim in June 2017 is not synonymous with the other items listed with it in the specification. *Id*. Aside from the claims themselves, the term "grille" is used twice in the specification. For example: "The front surface 220 may be substantially flat, though may include other surface configurations such [as] contours, corrugations, depressions, extensions, grilles, and so on, based on intended applications." '806 Patent Col. 7:12-15; *see also id*. 9:60-62. Shure contends that a "grille" is not similar enough to a "contour" or "corrugation," and as a result, the additions of the term "grille" to the specification and to Claim 5 should have been rejected as new matter. R. 399-1, Shure Am. Final Invalidity Content. Exh. 1 at 44.

But a "grille" is not categorically dissimilar to contours, corrugations, and depressions. As the language of the patent suggests, they are all "surface configurations" of the tile. In other words, all the items in the list describe the design or pattern of the material making up the room-facing surface of the tile. The bottom

line is that it is clear what a grille is (so it is reasonably certain what it is being claimed), and it is not so incongruous with other items listed in the original filing that it creates a substantial question of the '806 Patent's validity.

c. Claim 6

Third, Shure argues that Claim 6 is indefinite because it requires an "outer surface" to be "coplanar" with "said ceiling tile," even though—according to Shure—the "outer surface" is elsewhere defined as the outer surface *of* the ceiling tile. '806 Patent Col. 13:6-7; R. 402, Shure Resp. at 30-31 (redacted). In its reply, ClearOne argues that it would be possible to have one product, described in Claim 6, in which "the outer surface of the apparatus is on the same plane as the drop ceiling," and another product, described in Claim 7, in which "the outer surface extends below the plane of the drop ceiling." ClearOne Reply at 15 (redacted). At the claim construction stage, perhaps in an attempt to avoid the vice of indefiniteness in Claim 6, ClearOne additionally proposed a different construction of the terms in Claim 6, namely, "wherein said outer surface is *configured to be* on the same plane as the plane of said ceiling tile." R. 520, ClearOne Claim Const. Resp. at 34-35 (emphasis added) (redacted); Claim Const. Hrg. Tr. at 83:14-15 ("ClearOne has offered a claim construction for that term because Shure has argued that th[e] term is indefinite."). Shure, on the other hand, argues that the claim term is "not amenable to construction" because it is indefinite under 35 U.S.C. § 112(b). R. 508, Shure Claim Const. Br. at 34-35.

The language of the Claim is not indefinite as written. It is possible for an apparatus to have an outer surface that is part of the apparatus but also be considered distinct from the rest of it. In that scenario, the outer surface could be either "coplanar" with the apparatus itself (precisely what Claim 6 sets forth) or it could be an additional structure that—although still part of the apparatus—is lower than the rest of the tile, as in Claim 7. Claim 5 helps illustrate that point. There, the "outer surface comprises a grille." '806 Patent 13:40-41. A grille is an outer surface that, while considered part of the tile, could either be located right along the plane of the tile, or a few inches (for example) below it. In either scenario, the grille is still part of the tile. It is simply incorrect that the surface of a thing can never be lower than the thing itself, especially if the "thing" is comprised of various parts. Consider, for example, a light fixture dropping down from the ceiling. One part of the fixture could be a decorative cover that is still considered part of the fixture, but is lower than the rest of it. So too with the outer surface of a ceiling tile. There is no indefiniteness problem here.[16]

[16]There seems to be another issue, which is whether the "outer surface" referred to in Claim 6 is the outer surface of the BFMA, rather than the outer surface of the tile. ClearOne made arguments at the claim construction hearing that suggested it hopes the outer surface will be understood as that of the BFMA rather than the tile. *See, e.g.*, Claim Const. Hrg. Tr. at 84:5-12 ("[T]he patent discusses the plane of an array and also discusses the plane of the drop ceiling … in which the front surface of the ceiling tile is dropped below the plane of the array and below the plane of the drop ceiling so as to move the microphones of the array away from the drop ceiling."). The confusion seems to stem from a specification in the patent that refers to the "front surface of the Array 116" and describes a scenario in which the front surface of the BFMA and the tile line up (rather than the tile and its own outer surface). *See* '806 Patent Col. 9:38-45. To be clear—the language in Column 9 notwithstanding—the "said outer surface" in Claim 6 *cannot* refer to the outer surface of the BFMA. In Claim 6, "said outer surface" clearly refers back to Limitation 2 of Claim 1, which discloses "a ceiling tile with an outer surface on the front side of said ceiling tile wherein said outer surface is acoustically transparent." *Id.* Col. 13:18-20. Claim 6, as a dependent claim of Claim 1, of

Having decided that Claim 6 is not indefinite, the next question is whether it needs to be interpreted. ClearOne's proposed construction modifies the language of the patent only slightly, by adding three words: "configured to be." But ClearOne fails to provide a convincing reason for why a jury needs "configured to be" in order to understand the Claim, and it is not clear how "configured to be" makes the Claim *more* definite or would otherwise mitigate the potential issue that Shure has raised (which in any case, as explained above, is not a fatal one). *See generally*, R. 520, ClearOne Claim Const. Resp. at 34-35 (redacted). So the Court need not construe the language of Claim 6. It will be read for its plain and ordinary meaning, and it is not indefinite under 35 U.S.C. § 112(b).

D. Irreparable Harm

Moving on from the infringement and invalidity issues (which address the likelihood of success), the next question is whether ClearOne has clearly shown that it is suffering irreparable harm without an adequate legal remedy. Specifically, when a party seeks the extraordinary remedy of a preliminary injunction, it "must make a clear showing that it is at risk of irreparable harm, which entails showing a likelihood of substantial and immediate irreparable injury." *Apple, Inc. v. Samsung Elecs. Co. Ltd.,* 678 F.3d 1314, 1325 (Fed. Cir. 2012) ("*Apple I*") (cleaned up). For the harm

course, invokes that language directly: "The claim according to claim 1, wherein *said* outer surface is coplanar with said ceiling tile." *Id.* Col. 13:42-43 (emphasis added). So, the "said" outer surface is the outer surface of the *tile*—not the outer surface of the BFMA (which is still part of the apparatus and integrated with the ceiling tile). *See* Claim Const. Hrg. Tr. at 86:24-87:7 (counsel for Shure drawing the same distinction). Claim 5 supports the same reading: while a BFMA is unlikely to have a grille as an outer surface, a ceiling tile apparatus certainly could. *See* '806 Patent Col. 13:40-41.

inquiry, the Court considers factors like "the nature of competition between the patentee and the infringer, the willingness [(or refusal)] of a patentee to license, and any lost sales the patentee has proven." *Presidio Components, Inc. v. Am. Tech. Ceramics Corp.*, 875 F.3d 1369, 1383 (Fed. Cir. 2017). In addition to harm, the patentee must show that there is a "sufficiently strong causal nexus" between the harm and the infringement. *Apple Inc. v. Samsung Elecs. Co., Ltd.*, 695 F.3d 1370, 1374 (Fed. Cir. 2012) ("*Apple II*"). ClearOne has met its burden of showing both harm and causal nexus.

1. Harm

The Court has previously found that Shure's sale of the MXA910 is harming ClearOne, R. 279, Mem. Op. and Order (redacted), and many of the facts that established harm in the context of the '186 Patent are still true now. For example, ClearOne lost opportunities to install its microphones at [redacted], as well as at [redacted], and some of ClearOne's existing customers have started switching to Shure microphones. *Id.*; R. 363, Waadevig Rep. ¶¶ 69-71; 74 (sealed).

Since then, ClearOne has learned about additional sales that it has lost to the MXA910. First, ClearOne lost a sale to American Water, which chose the MXA910 at least in part because it could be integrated into a drop ceiling. R. 361, DiCampello Decl. ¶¶ 12-18 (sealed); R. 362, Waadevig Rep. ¶ 69(a) (redacted). American Water was previously a ClearOne end user, R. 371, DiCampello Decl ¶ 12 (redacted), and according to the audio integrator (essentially the distributor-installer of conferencing

systems), the lost sale was worth around $140,000, *id.* ¶ 16 (redacted). Also, ClearOne recently learned that it lost a sale to Bristol-Myers Squibb, which instead went with Shure after a side-by-side comparison (or "shoot-out") in which ClearOne believes its audio actually performed better than the MXA910's. R. 371, DiCampello Decl. ¶¶ 19-23 (redacted); R. 362, Waadevig Rep. ¶ 69(b) (redacted). Finally, ClearOne lost a sale to a "major hardware and software company." R. 364, Hakimoglu Decl. ¶¶ 19-22 (redacted); R. 362, Waadevig Rep. ¶ 69(c) (redacted). Although the company does allow different end users at different locations to use different audio conferencing equipment, the end users at the company apparently typically prefer the MXA910 because it "remain[s] out of sight in a ceiling tile." R. 364, Hakimoglu Decl. ¶ 22 (redacted). ClearOne has identified several other end users and integrators with which it may have lost opportunities over the past months. R. 363, Waadevig Rep. ¶ 71 (sealed).

As the Court found in the context of the '186 Patent, lost sales in the installed audio-conferencing market are particularly devastating because end users often use the same brand of audio conferencing equipment throughout their facilities and because sales tend to be infrequent given the long life-span of the equipment. *See* R. 279, Mem. Op. and Order. at 41 (redacted); R. 364, Hakimoglu Decl. ¶ 15 ("Customers purchase installed audio conferencing products rarely, so those who have already installed an MXA910 are unlikely to purchase a replacement for several years.") (redacted); R. 362, Waadevig Rep. ¶ 67 ("[B]ecause audio conferencing products are expensive and durable, end users typically will not purchase an upgrade for several

years.") (redacted). The dynamics of the installed audio conferencing market and the technology itself contribute to a scenario where integrators and end users are incentivized to stick with one vendor or product for as long as is feasible. R. 362, Waadevig Rep. ¶¶ 40-41 (describing how audio conferencing end users "prefer[] to deal with the same vendor for all their installed audio conferencing needs" and the reasons why) (redacted); *id*. ¶¶ 49-52 (explaining the factors that contribute to the high cost of switching vendors for most integrators and consultants) (redacted); *id*. ¶ 59 (pointing out that purchasers often buy in volume to outfit as many conference rooms as possible) (redacted). ClearOne believes this to be the case for Bristol-Myers Squib: it was the understanding of one of ClearOne's sales managers, Jason DiCampello, "that in choosing the MXA910, Bristol-Myers was selecting the beamforming microphone with which it will standardize its facilities for the foreseeable future." R. 371, DiCampello Decl. ¶ 24 (redacted).

ClearOne also maintains that it continues to suffer other intangible harms, like loss of customer goodwill and reputation. ClearOne's BMA-1 used to be "the only beamforming microphone of its kind." R. 371, DiCampello Decl. ¶ 6 (redacted). Now, ClearOne is concerned that it is no longer the "cool new product," and that instead, Shure's MXA910 is. *Id*. ¶ 17 (redacted). ClearOne's evidence shows that "this reputation matters" to consultants and integrators. *Id*. (redacted). And it is not clear that whenever ClearOne releases its own product practicing the '806 Patent it will regain its reputation. R. 361, DiCampello Decl. ¶ 10 [redacted]

[redacted] (sealed); R. 365, Hakimoglu Decl. ¶ 16 [redacted] (sealed). Waadevig agrees. R. 362, Waadevig Rep. ¶¶ 79-86 (explaining that integrators and purchasers are more likely to "invest in their relationship[s]" with "vendors who are perceived as thought leaders.") (redacted).

ClearOne's loss of market share is the starkest evidence of the harm it has suffered and is likely to continue to suffer. Almost immediately after the MXA910 was released in 2016, ClearOne's BMA sales declined. R. 363, Waadevig Rep. ¶¶ 87-91 (sealed). ClearOne's DSP sales have also decreased, in part because the MXA910 can be used with several different DSPs, while the BMA-1 requires use of ClearOne's. *Id*. ¶¶ 92-93. These sales losses also have led ClearOne to drop prices on all its DSP platforms more than the industry average. *Id*. ¶¶ 96-97 (identifying several reasons for the DSP price drops, but claiming they are in part "an attempt to compete on price with Shure's MXA910 and compatible DSP products."). ClearOne has learned of additional lost sales, and its stock price has continued to plummet. R. 364, Hakimoglu Decl. ¶ 12 (redacted).

It also remains the case that ClearOne refuses to license its technology, including the '806 Patent. ClearOne's CEO, Zee Hakimoglu, continues to maintain that ClearOne has no plans to license the '806 Patent's technology, in part because "[n]o license could make up for" losing exclusive control of its patented technology. R. 365, Hakimoglu Decl. ¶¶ 17-18 (sealed). As the Federal Circuit has held,

unwillingness to license weighs in favor of a finding of irreparable harm. *See Presidio*, 702 F.2d at 1363; *Douglas Dynamics, LLC v. Buyers Prods. Co.*, 717 F.3d 1336,1345 (Fed. Cir. 2013).

Shure has argued in this litigation that more installed audio conferencing devices are now on the market, and that the increased competition changes the calculus from when the Court decided the analogous issue in ClearOne's favor for the '186 Patent. *See* Shure Resp. at 38-39. Shure's Senior Director, Chad Wiggins, has described several wall- and ceiling-mounted beamforming products that have become more prominent in the audio conferencing market since the '186 Patent litigation. R. 418, Wiggins Decl. ¶¶ 19-21 (sealed). Those include a product produced by Sennheiser, similar to the MXA910, which has allegedly become more competitive in price in recent months. *Id.* ¶¶ 20-21 (sealed); *see also* R. 442, Giza Exh. 137, Wiggins Dep. Tr. at 145:15-146:10 (explaining Sennheiser's price changes, as well as other efforts Sennheiser has allegedly made to compete directly with Shure's MXA910) (sealed). ClearOne disputes that there has been a real change in circumstances and points out that many, if not all, of these competing products also existed before the '186 Patent litigation. R. 439, ClearOne Resp. at 19 (sealed); *see* R. 442, Giza Exh. 137, Wiggins Dep. Tr. at 114:10-116:12, 148:19-151:23 (sealed).

But more importantly, there is no disagreement that ClearOne's BMA directly competes with Shure's MXA910 in the installed audio conferencing market. R. 440, ClearOne Reply at 19 (redacted). Both products are "installed audio conferencing endpoints." R. 362, Waadevig Rep. ¶ 24 (redacted). And as described above, there is

ample evidence that they have previously competed directly for several different sales. That is an important factor: The Federal Circuit has held that direct competition is "one factor suggesting strongly the potential for irreparable harm." *Apple, Inc. v. Samsung Elecs. Co., Ltd.*, 809 F.3d 633, 653-54 (Fed. Cir. 2015) ("*Apple IV*") (cleaned up); *Douglas*, 717 F.3d at 1344-45. There is simply no requirement that the ClearOne BMA and the Shure MXA910 be the *only* products on the market. *Robert Bosch LLC v. Pylon Mfg. Corp.*, 659 F.3d 1142, 1151 (Fed. Cir. 2011) ("[W]ithout additional facts showing that the presence of additional competitors renders the infringer's harm reparable, the absence of a two-supplier market does not weigh against a finding of irreparable harm.").

2. Nexus

ClearOne has established that its injuries are caused at least in part by the infringing aspects of Shure's MXA910. It is worth clarifying at the outset that ClearOne does not need to show that the patented features of its product are the only or even the main reason for consumer demand for it. *See Genband US LLC v. Metaswitch Networks Corp.*, 861 F.3d 1378, 1382-84 (Fed. Cir. 2017) (explaining that the patented feature need only be "*a* driver" rather than "*the* driver" of demand). Instead, ClearOne need only show "some connection between the patented feature and demand." *Apple, Inc. v. Samsung Elecs. Co., Ltd.*, 735 F.3d 1352, 1364 (Fed. Cir. 2013) ("*Apple III*"). This can be done in a number of ways, including by showing that the patented features are one of many factors in consumers' purchasing decisions, or by showing that the presence of the patented features makes the product significantly

more desirable. *Id.*; *see also Apple IV*, 809 F.3d at 644 (holding that causal nexus was established by showing that the features at issue "were important to customers when they were examining their phone choices").

There is clearly a nexus between ClearOne's loss of sales, market share, and reputation, and the MXA910's integration of a BFMA with a ceiling tile that can be mounted flush in a drop ceiling. As noted above, ClearOne lost a sale to American Water in part because the MXA910 could be integrated into a drop ceiling. ClearOne has also heard from at least one integrator that "its end user customers prefer the MXA910's form factor over the BMA's due to the MXA910's aesthetic appeal—specifically, because it can drop right into a ceiling tile." R. 371, DiCampello Decl. ¶ 8 (redacted). The integrator liked the MXA910 for that reason, too. *Id.* (redacted). ClearOne's expert, Paul Waadevig, has also explained why the flush mounting option is appealing to so many: "[T]he visual integration of such a product into a conference room is important as well. … [I]nstalled audio end users prefer conferencing products that … are also unobtrusive once installed." R. 362, Waadevig Rep. ¶¶ 31, 35 ("Because [the MXA910] finally satisfies the demand for a seamlessly-integrated, high-quality installed audio microphone, it is highly innovative.") (redacted). In response, Shure offers other reasons for the MXA910's success, focusing in particular on its adjustable lobes and easy user interface. R. 418, Wiggins Decl. ¶¶ 11, 15 (sealed). But ultimately Wiggins (Shure's own executive) acknowledges that "some customers appreciate the ability to package in a 2' x 2' drop ceiling grid square." *Id.*; *see also* R. 442, Giza Exh. 137, Wiggins Dep. Tr. at 181:25-182:5 ("I would agree that

the ability to be hung flush in a two-by-two drop ceiling grid is one of the reasons for the [MXA910's] success, along with dozens of [] other drivers.") (sealed).

Shure also points to evidence that there were other issues with the production and sale of ClearOne's BMA, suggesting that ClearOne's drop in market share is less a result of competition from the MXA910 and more the natural consequence of its alleged low quality. Shure also points out that ClearOne's BMA only works with ClearOne's own DSP unit, and that it does not allow for adjustable beams. R. 413, Shure Resp. at 37-38 (sealed). Also, Shure points to emails and other communications between ClearOne managers and employees and its end users and integrators, all [redacted]

Id. at 38 (sealed) (citing R. 422, Patel Exh. 73-78 (sealed)). But some of the communications identified by Shure do not relate to the quality of the products themselves. For example, an email exchange between Hakimoglu and a product line manager in April 2015 appears to have more to do with preparation than function. *See generally* R. 422, Patel Exh. 78 [redacted] (sealed). But in any case, Shure has not presented any evidence actually linking these anecdotes to the BMA's poor performance against the MXA910.

At the hearing, Shure also argued that the presence of other competitors of ClearOne's BMA would make it difficult to remedy the harm suffered by ClearOne by enjoining Shure. That is, to Shure's way of thinking, any sales that would have gone to the MXA910 might not go to ClearOne's BMA anyway. Prelim. Inj. Hrg. Tr. at

150:10-152:1. But the presence of other competitors does not weaken ClearOne's rights under its patent. If ClearOne believes that other potential competitors are infringing the patent, then it may choose to litigate against them as well. And in any case, even if some of the displaced sales went to companies other than ClearOne, the fact that Shure would not gain those customers would prevent ClearOne from having to compete against Shure to regain them in the future. Also, because ClearOne hopes to develop its own practicing product soon, it *may* get the sales Shure would lose. *See* R. 365, Hakimoglu Decl. ¶ 14 (sealed).

Finally, in its response to ClearOne's motion, Shure asserted that, because ClearOne did not yet market a product practicing the '806 Patent, "its theory of irreparable harm [was] even more convoluted." R. 402, Shure Resp. at 37 (redacted). But ClearOne was not required to practice the patent to be irreparably harmed by Shure's infringement of it. *See Presidio*, 702 F.3d at 1363 ("Even without practicing the claimed invention, the patentee can suffer irreparable injury. Direct competition in the same market is certainly one factor suggesting strongly the potential for irreparable harm without enforcement of the right to exclude."). At any rate, ClearOne has since announced that it has begun selling a product that practices the '806 Patent. *See* R. 479, Not. of Release of Product. But the new product does not significantly change the analysis: the evidence was already clear that the BMA itself had been competing directly—albeit unsuccessfully—with the MXA910.

Relatedly, Shure also seems to argue that it is implausible that the MXA910 could harm ClearOne by infringing both the '186 Patent and the '806 Patent. R. 402,

Shure Resp. at 37 ("ClearOne has already argued that its harm has been caused by Shure's alleged infringement of the '186 Patent. Now it uses its same charts and same data to allege that same harm is *actually* caused by the '186 Patent") (redacted). But there is nothing odd about competing products having different features that contribute to customer buying decisions. And, as discussed above, the evidence clearly proves that the BMA-tile integration is a material factor in customers' decision-making.

E. Inadequate Remedy at Law

The question of adequate remedy at law is often closely related to the irreparable harm inquiry. As explained above, ClearOne has shown that it is losing sales to Shure and is likely to lose more. The structure of the market makes it hard to measure the impact of these sales. As discussed earlier in the Opinion, a single lost sale could mean a loss of yet more business down the road, because integrators and users prefer to stick with the audio technology they know. And it is difficult to know with certainty even which sales have been lost thus far, because neither company sells directly to its end users. R. 362, Waadevig Rep. ¶ 72 (redacted). From this evidence, it is clear that money damages would be difficult to quantify, which is evidence that remedies at law are inadequate to compensate for the harm. *Metalcraft of Mayville, Inc. v. The Toro Co.*, 848 F.3d 1358, 1368 (Fed. Cir. 2017) ("Where the injury cannot be quantified, no amount of money damages is calculable, and therefore the harm cannot be adequately compensated and is irreparable."); *i4i Ltd. P'ship v. Microsoft Corp.*, 598 F.3d 831, 862 (Fed. Cir. 2010); *Broadcom Corp. v. Qualcomm*

Inc., 543 F.3d 683, 703-04 (Fed. Cir. 2008). ClearOne has also pointed to evidence of other hard-to-measure harms, such as the loss of its reputation as a market-leading innovator. ClearOne affirms that it has no plans to license the patented technology because it benefits so much from exclusivity. R. 365, Hakimoglu Decl. ¶¶ 17-18 (sealed). This loss of exclusivity cannot easily be made whole by money damages. *See Douglas*, 7171 F.3d at 1345 (holding that remedies at law were inadequate to compensate patentee's reputation loss from infringement); *i4i*, 598 F.3d at 862. An injunction is the right remedy for these harms.

F. Balance of Harms and the Public Interest

The last two preliminary-injunction factors ask the Court to weigh the relative costs and benefits of an injunction to ClearOne and Shure, and to examine whether an injunction is in the public interest. *Metalcraft*, 848 F.3d at 1369, (citing *Luminara Wordwide, LLC v. Liown Elecs. Co. Ltd.*, 814 F.3d 1343, 1352 (Fed. Cir. 2016)).

To be clear at the outset, Shure's MXA910 has multiple mounting options, and ClearOne has only alleged that one of them—its drop ceiling mounting configuration—is infringing. *See also* R. 402, Shure Resp. at 32 ("By suggesting the MXA910's success is due to one of four optional mounting configurations, ClearOne ignores the real reasons for the success.") (redacted). So an appropriately tailored preliminary injunction in this case would only prohibit Shure from selling the MXA910 to be used in a drop ceiling mounting configuration—it would not impede Shure's ability to sell the MXA910 for use in other configurations. Additionally, the Court has the discretion to limit the harm to end users who have already installed

the MXA910 in a drop ceiling configuration to continue using it that way, and by allowing Shure to continue servicing those customers.

It is true that the preliminary injunction will impose substantial costs on Shure. Shure would have to modify its promotional and marketing materials, and would very likely lose at least some sales to customers interested solely in drop-ceiling-mounted audio conferencing products.

But Shure does not know how many of its MXA910 sales end up mounted in drop ceiling configurations. R. 418, Wiggins Decl. ¶¶ 8-9 (sealed). The only benchmark it has is the number of special brackets it has sold for mounting the MXA910 to a *hard* ceiling. Even this is a rough gauge because customers can also use suspension mounting to install the MXA910 in a room with a hard ceiling, or buy a different Video Electronics Standards Association (VESA) bracket. R. 410, Wiggins Decl. ¶¶ 6-7 (redacted). But Shure has sold over [redacted] hard-ceiling mounting brackets, which suggests that at least some portion of its customer base uses the MXA910 with a hard ceiling—not in a drop ceiling. R. 418, Wiggins Decl. ¶ 8-9 (sealed).

Shure's uncertainty about how its MXA910s are most often installed makes it difficult to know precisely how much harm Shure would suffer under an injunction. That is not necessarily a problem: because the MXA910 only infringes ClearOne's patent when mounted in a drop ceiling configuration, ClearOne's harm without an injunction is directly related to the number of MXA910s that would be sold for the drop-ceiling mounting. And in any case, because Shure argues that its drop ceiling

mounting option is *not* the primary reason for the MXA910's success, R. 402, Shure Resp. at 32 (redacted), end users who are attracted to the MXA910 for any of its other advantages might not be put off by their inability to mount it in a drop-ceiling grid. And that means it may not expect to see significant losses from an injunction tailored specifically to the drop ceiling mounting configuration.

Of course, in addition to its effect on Shure, an injunction would impose costs on the public. Shure's MXA910 might very well have advantages beyond the fact that it can mount cleanly into a drop ceiling. In addition, because ClearOne is not currently practicing the patent, it is not clear that the public will be able to purchase a practicing product while the injunction is in place. But any harms from loss of competition should be offset by the benefits of the injunction to the public: the point of granting a period of exclusivity over patented technology is to reward innovation and investment in research. The public benefits when this system works, and suffers when patents are infringed, so it is in the public interest—in the long run—to protect valid patents. *See Douglas*, 717 F.3d at 1346 ("While the general public certainly enjoys lower prices, cheap copies of patented inventions have the effect of inhibiting innovation and incentive."); *Broadcom*, 543 F.3d at 704 (agreeing that "it is generally in the public interest to uphold patent rights").

IV. Conclusion

For all the reasons detailed above, ClearOne has established that it is likely to succeed on the merits: Shure is likely infringing the '806 Patent, and it has failed to raise a substantial question of the patent's validity. In addition, ClearOne is suffering

irreparable harm from Shure's infringement, and the balance of the harms and the public interest both weigh in favor of issuing an injunction against Shure's infringing sales of the MXA910 going forward. In order to ensure that harm to ClearOne is minimized without placing an unfair burden on Shure, the tailored preliminary injunction is this:

> Shure shall cease manufacturing, marketing, and selling the MXA910 to be used in its drop-ceiling mounting configuration, including marketing and selling the MXA910 in a way that encourages or allows integrators to install it in a drop-ceiling mounting configuration. This injunction applies to Shure's officers, agents, servants, employees, and attorneys, as well as anyone who is in active concert or participation with those listed persons. But Shure customers that have already installed the MXA910 in a drop-ceiling mounting configuration shall be permitted to continue using their MXA910s in that way, and Shure will be able to continue servicing those already-installed products.

In the preliminary injunction briefing, the parties did not address the issue of the appropriate amount of the bond ClearOne will have to post under Federal Rule of Civil Procedure 65(c) before the preliminary injunction goes into effect. The parties shall promptly confer over the issue by 5 p.m. Central on August 6, 2019. Absent an agreement, ClearOne shall file its motion to set the security amount by 5 p.m. on August 7, 2019. Shure shall respond by 5 p.m. on August 9, 2019. ClearOne may reply by 5 p.m. on August 12, 2019 (all times Central). In light of the ongoing irreparable harm, these deadlines are not extendable absent extraordinary circumstances.

ENTERED:

s/Edmond E. Chang
Honorable Edmond E. Chang
United States District Judge

DATE: August 5, 2019

EXHIBIT Q

ClearOne

5225 Wiley Post Way, Suite 500 | Salt Lake City, UT 84116 TEL 801 975 7200 FAX 801 977 0087 www.clearone.com

August 29, 2019

Re: Installation of Shure MXA910 in a Drop-Ceiling Mounting Configuration

To Whom It May Concern:

It has long been ClearOne's position that any installation or use of an MXA910 product in a drop-ceiling mounting configuration infringes ClearOne's U.S. Patent No. 9,813,806 (the "'806 Patent"). On August 5, 2019, a Court Order confirmed ClearOne's position. In that Order, (available at https://is.gd/injuncn), the Court held that "Shure is likely infringing the '806 Patent" by manufacturing, marketing, and selling the MXA910 to be used in its drop-ceiling mounting configuration, and issued a preliminary injunction order preventing Shure from manufacturing, marketing, and selling its MXA910 product for use in a "drop-ceiling mounting configuration." The Court's order also prevents Shure from encouraging others to use the Shure MXA910 beamforming microphone array in the "drop-ceiling mounting configuration" and "applies to Shure's officers, agents, servants, employees, and attorneys, as well as anyone who is in active concert or participation with those listed persons."

The Court's infringement analysis applies equally to third parties such as integrators and consultants. If Shure is likely infringing the '806 Patent by manufacturing, marketing, and selling the MXA910 product to be used in a drop-ceiling mounting configuration, then third-party integrators are also likely infringing the '806 Patent if they install the MXA910 product in a drop-ceiling mounting configuration, and third-party consultants are likely inducing infringement if they recommend installation of the MXA910 product in a drop-ceiling mounting configuration.

Please be aware that it is likely an act of infringement to install a Shure MXA910 product (Model Nos. MXA910B, MXA910W, MXA910AL, MXA910B-60CM, MXA910W-60CM, and MXA910AL-60CM) in a drop-ceiling mounting configuration. This is so regardless of when, or how, the installing company received the MXA910 that it installs. Please also be aware that a finding of willful patent infringement may result in the infringer having to pay treble damages pursuant to 35 U.S.C. § 284.

We thank you in advance for your understanding of ClearOne's efforts to protect its intellectual property rights. Please contact me with any questions or concerns.

Very truly yours,

Narsi Narayanan
Senior Vice President of Finance
801-303-3588
narsi@clearone.com

EXHIBIT R

CLEARONE'S FALSE AND MISLEADING STATEMENTS REGARDING IMPACT OF RECENT COURT RULING IN THE U.S.

Dear Channel Partner,

As you know, Shure has been involved in patent litigation with its competitor ClearOne focusing on Shure's award winning MXA910 ceiling array microphone product. Earlier this spring and summer, Shure initiated its own lawsuit against ClearOne in federal court in Delaware because ClearOne was making and continues to make intentionally false, deceptive and misleading remarks to the marketplace about the impact of the patent litigation on the availability of Shure's MXA910 product. Shure believes in fair competition - but we will not tolerate ClearOne's deception, confusion and needless disruption of the marketplace, which is simply an attempt to disparage Shure in an attempt to sell its own products.

This letter is prompted by the fact that ClearOne recently distributed additional communications to the marketplace relating to the patent litigation. You may have received a letter dated August 29, 2019 from ClearOne's CFO Narsi Narayanan, in which ClearOne again tries to misinform, mislead, and seemingly intimidate and threaten customers in the marketplace, by both making false statements and omitting important facts about the scope and impact of the recent preliminary injunction granted by a federal court in Chicago on Shure's ability to supply and support MXA910 products. As before, the untruth of these marketplace statements has been examined by Shure's attorneys, and shortly, we will be amending our lawsuit in Delaware to include the falsity of the statements made in this recent ClearOne letter. But in the meantime, we wanted to take the opportunity to remind you of the limited effect of the Court's rulings.

As we have indicated in prior communications about how the preliminary injunction does (and does not) impact Shure's ability to supply and support MXA910 products:

- The injunction went into effect on Friday, August 23, 2019 when ClearOne posted the bond ordered by the Court;
- The scope of the injunction is limited to MXA910 products (MXA910B, MXA910W, and MXA910AL) supplied in and from the U.S., and does not

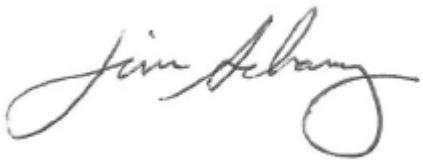
affect past or future sales of all MXA910 products abroad;

- The Court specifically recognized Shure's ability to continue selling the 60 cm version of the MXA910 product (MXA910B-60CM, MXA910W-60CM, and MXA910AL-60CM) in the U.S., which we are actively doing;
- Only one mounting configuration is impacted (**flush mounting** of an MXA910 in a drop ceiling grid). The other mounting configurations (pole mounting, cable suspension mounting, hard ceiling/surface mounting) have been specifically authorized by the Court;
- To address the one impacted configuration, Shure is expeditiously working on minor modifications to our MXA910 to allow it to be mounted in a drop ceiling grid, and we expect to release that solution in the very near future;
- As noted in the final paragraph of the Bond Order (see Link below), with respect to MXA910 products sold and delivered to integrator/installers prior to the injunction taking effect, recall of such units is not required regardless of the integrator/installers' intended mounting configuration for such products;
- The Court specifically recognized Shure's ability to continue to service and support previously installed MXA910 products, regardless of size or mounting configuration, and we will continue to do so.

While ClearOne's letter provides a link to the preliminary injunction order, the letter notably omits a subsequent order from the Court which clarifies the limited scope of the injunction and its effect. That clarifying Bond Order can be found here. We would encourage you to review it so that you can better understand the limited effect of the Court's order.

Shure is disappointed that ClearOne continues to drag our valued customers into this ongoing legal dispute through its obvious attempts to be disruptive to and confuse the marketplace, rather than fairly compete by promoting its own products. Rest assured that Shure remains committed to supporting its customers with best in class products, solutions, and service, as we have always done. Shure will provide the highest level of support, guidance, and needed resources to enable you to continue marketing and selling the MXA910 product in compliance with the Court's order. We will also be available to directly address any inquires or concerns from your customers. Please don't hesitate to contact your Sales Managers for support, or click here to submit a question to Shure on these issues.

Sincerely,



Jim Schanz

Vice President, Global Integrated Systems Sales
Shure Inc.

Shure Incorporated
5800 W Touhy Ave
Niles, IL 60714-4608 USA

Contact Us

CERTIFICATE OF SERVICE

I, Sourabh Mishra, hereby certify that on December 16, 2019, the publicly-available version of the foregoing document was filed electronically through the Court's Electronic Case Filing System. and thereby available to counsel of record. The version filed under seal was delivered electronically to counsel of record for Defendant Shure Incorporated.

By: */s/ Sourabh Mishra*